PIBS 2564E

WATER PLANT OPTIMIZATION STUDY

COMPENDIUM REPORT

MARCH 1995

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Ministry of
Environment
and Energy

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REFERENCE NOTE

The activities described in this report were partially carried out when this Ministry was the Ministry of the Environment (MOE). In February 1993, the MOE was merged with the Ministry of Energy to form the new Ministry of Environment and Energy (MOEE). Notations in this report of MOE refer to activities prior to February 1993. When MOEE is used, it refers to events or activities after February 1993.

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1.0 INTRODUCTION

1.1 Background

Several developments in the 1980s led to the implementation of water plant optimization activities in Ontario. First, the Ontario Ministry of the Environment (MOE) initiated the Drinking Water Surveillance Program in 1985, which for the first time provided utilities and the public with up-to-date, detailed, and reliable data on drinking water quality. Second, the attention of the water industry was focused in 1986 on the USEPA amendments to their Safe Drinking Water Act (SDWA), and what the implications of a similar move would be in Ontario. The SDWA required the regulation of 83 contaminants of concern by 1989. Third, in 1986 several water supplies in the St. Clair River corridor were threatened by highly publicized toxic industrial discharges. Due to these events there was considerable pressure on the MOE to build emerging and costly treatment technologies into an overall treatment strategy. Instead of costly plant upgrades, the MOE's approach was to examine the quality of water that could be attained by making the best use of existing facilities. This was the philosophy behind the Water Plant Optimization Study.

The Water Plant Optimization Study (WPOS) was initiated in 1987 for 44 water supply systems (41 treatment plants and 3 groundwater well systems) located throughout the Province. The systems were operated by municipalities (33) and MOE (11). These 44 supplies covered approximately 70 percent of the provincial population served by piped water and provided good geographic coverage of the Province. All studies were completed by 1993.

The purpose of the WPOS was to document and review the existing conditions at each of the water supply systems being studied and to determine an optimum treatment strategy at each plant, with emphasis on the particulate removal and disinfection processes. To this end, a plant investigation and process evaluation study was required for each plant or supply system included in the

program. The Optimization Protocol and General Terms of Reference used for each study are included in Appendix II. Each study was carried out according to a number of sequential tasks, generally consisting of:

- project initiation;
- documentation/verification of raw and treated water quantity and quality;
- documentation and verification of the plant treatment processes and operating procedures;
- particulate removal assessment using existing capital works;
- disinfection assessment using existing capital works;
- short and long-term modifications for improved performance; and
- final report summarizing all findings and recommendations.

1.2 Methodology

The WPOS was organized with a team approach in mind. The process of optimization was carried out by a team that included Ministry of the Environment scientific and technical staff, consulting engineers, and utility management and operations personnel.

Each individual Plant Study was conducted by a Plant Consultant, who was expected to provide experienced staff to gather and interpret plant operating data, provide recommendations for obtaining optimum particulate removal and disinfection, and complete all other required work.

A Project Committee was struck for each of the individual plant studies, and consisted of utility and MOE representatives. This committee created site-specific terms of reference for the plant study using the general terms of reference as the basis. The Project Committee: directed the Plant Consultant in carrying out the work as specified in the site-specific terms of reference; reviewed the progress of the work; and evaluated all progress reports and the final report for each study.

A Prime Consultant was selected to coordinate all of the individual plant studies. The Prime Consultant was a member of each of the individual Project Committees and carried out all liaison between the Project Committee and Plant Consultant.

The administrative and technical direction for the entire study was provided by a Coordination Group comprised of MOE personnel. The Coordination Group was directly responsible for the development of the initial Optimization Protocol and Process Monitoring Reporting Protocol. They co-ordinated the selection of the various plant consultants and directed the co-ordination of the 41 individual optimization studies through the Prime Consultant.

Outlined below is the organization of the team approach which was used for the study. The various members of the team were:

MOE Coordination Group

- Ken Roberts, Manager
  Drinking Water Section (Water Resources Branch)

- Ron Hunsinger, Assessment Group Head
  Drinking Water Section (Water Resources Branch)

- Gary Martin, Coordinator Field Services
  Drinking Water Section (Water Resources Branch)

- Janusz Budziakowski, Senior Engineer
  Municipal Approvals Section (Approvals Branch)

- Bill Gregson, Senior Project Engineer
  Project Engineering Branch

Prime Consultant

- Gerry Sigal, R.V. Anderson Associates Limited

Project Committees (41)

- Prime Consultant
- MOE Water Resources Branch Representative
- MOE Project Engineering Branch Representative
- MOE Approvals Branch Representative
- MOE Regional Representative
- Municipal Management Representative
- Municipal Operations Representative

Plant Consultants

- Eleven Consulting Engineering Firms

1.3 Plant Studies

The original WPOS schedule called for 41 water plants to be studied. These 41 plants were in 35 communities spread over the six MOE Regions (three plants were studied in Toronto; two plants were studied in Ottawa, Sault Ste. Marie, Thunder Bay and Sudbury). The plants which were studied are listed in Table 1 along with the Plant Consultant for each study.

Most of the supply systems utilized surface water. The water supplies at Stouffville and Kitchener were groundwater well systems, as was one of the supplies for Sault Ste. Marie. During the Port Dover study, it was found that Port Dover had two supplies - a treatment plant and an infiltration gallery. These were dealt with in a single report. The study for Timmins revealed three separate supplies - a treatment plant, a well supply and a remote treatment plant using granular activated carbon contactors. The three were included in one report.

TABLE 1. Water Supply Systems Studied

MOE REGION	WATER SUPPLY SYSTEM	PLANT CONSULTANT
Southwestern	St. Thomas (Elgin Area)	MacLaren Engineers Inc.
	Leamington (Union Area)	LaFontaine, Cowie, Burrato & Assoc.
	Amherstburg	LaFontaine, Cowie, Burrato & Assoc.
	Wallaceburg	Gore & Storrie Ltd.
	Windsor	Gore & Storrie Ltd.
	London (Lake Huron Area)	MacLaren Engineers Inc.
	Mitchell's Bay	M.M. Dillon Ltd.
	Belle River	LaFontaine, Cowie, Burrato & Assoc.
	Walpole Island	R.J. Burnside & Associates Ltd.
	Stoney Point	LaFontaine, Cowie, Burrato & Assoc.
	Tilbury	LaFontaine, Cowie, Burrato & Assoc.
	Sarnia (Lambton Area)	M.M. Dillon Ltd.
	Dresden	M.M. Dillon Ltd.
West Central	Hamilton	Pollutech Ltd.
	Port Dover	Simcoe Engineering Group Ltd.
	Kitchener	M.M. Dillon Ltd.
	Brantford	Simcoe Engineering Group Ltd.
	Grimsby	MacLaren Engineering Inc.
	Fort Erie	Proctor & Redfern Ltd.
	St. Catharines	Gore & Storrie Ltd.
	Niagara Falls	Gore & Storrie Ltd.

TABLE 1 (cont.'d). Water Supply Systems Studied

MOE REGION	WATER SUPPLY SYSTEM	PLANT CONSULTANT
Central	South Peel (Lakeview)	Gore & Storrie Ltd.
	Oshawa	Gore & Storrie Ltd.
	Toronto (R.C. Harris)	Gore & Storrie Ltd.
	Toronto (R.L. Clark)	MacLaren Engineers Inc.
	Toronto (Easterly)	MacLaren Engineers Inc.
	Stouffville	Canviro Consultants Ltd.
	Burlington	Simcoe Engineering Group Ltd.
	Peterborough	Gore & Storrie Ltd.
Southeastern	Belleville	Gore & Storrie Ltd.
	Cornwall	Gore & Storrie Ltd.
	Kingston	Gore & Storrie Ltd.
	Ottawa (Brittania)	Canviro Consultants Ltd.
	Ottawa (Lemieux)	Canviro Consultants Ltd.
	Odessa	Canviro Consultants Ltd.
	Deseronto	Canviro Consultants Ltd.
Northeastern	Sault Ste. Marie (Plant)	Proctor & Redfern Ltd.
	Sault Ste. Marie (Wells)	Proctor & Redfern Ltd.
	Sudbury (David St.)	Sandwell Swan Wooster Inc.
	Sudbury (Wanapitei)	Sandwell Swan Wooster Inc.
	Timmins	J.L. Richards Associates Ltd.
	North Bay	Proctor & Redfern Ltd.
Northwestern	Thunder Bay (Bare Point)	Proctor & Redfern Ltd.
	Thunder Bay (Loch Lomond)	Proctor & Redfern Ltd.

During the study period, the Coordination Group decided that the two studies for Sudbury, the two for Sault Ste. Marie, and the two for Thunder Bay should each be combined into one individual report. The three studies for Toronto and the two for Ottawa all remained as separate reports.

In addition to the 41 systems originally scheduled to be studied, the Ministry initiated studies for Dresden, Odessa, and Deseronto because conditions at these supply systems were determined to warrant the need for an optimization study at that time.

1.4 Plant Study Summaries

Summaries of the final reports that were written for each of the 44 supplies studied may be found in the report entitled "Water Plant Optimization Study - Plant Study Summary Report", which may be obtained from the MOEE Science and Technology Branch, Water and Wastewater Optimization Section, 125 Resources Road, Etobicoke, Ontario M9P-3V6. Although Sault Ste. Marie, Thunder Bay and Sudbury each had two plant studies which were combined into one report, the summaries for each plant study are presented in the above report.

Each summary presents information such as the municipalities and population served, raw water source, location, system flows and capacity. Brief outlines of the supply's history, processes and operation are given. Summaries of raw and treated water quality are presented, as well as profiles of raw and treated water turbidity during the study period. The consultant's recommendations are also highlighted.

2.0 OVERALL STUDY RESULTS

2.1 General

A major goal of the WPOS, in addition to the optimization of 44 water supplies, was to identify the nature of the problems facing these supplies in order to more effectively target future optimization efforts. The 44 supplies are representative of a wide range of supplies in Ontario in terms of geographic location, raw water types and capacity, thereby making it possible to arrive at some general conclusions regarding the condition of water plants in Ontario.

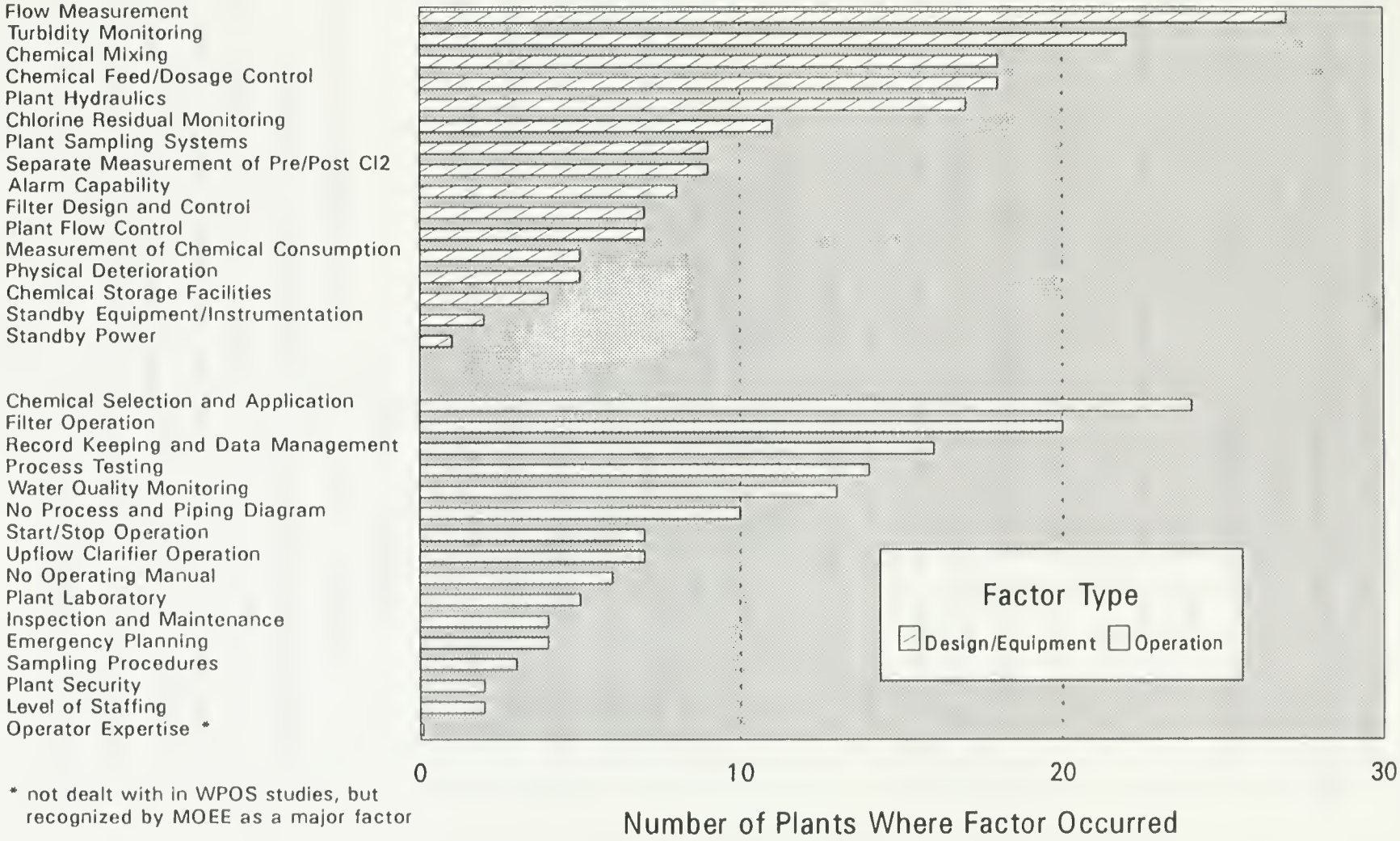
Short and long-term recommendations were made by the consultants, focusing on aspects of plant design and operation that inhibit plant performance. An examination of the recommendations in the 44 study reports resulted in the identification of 32 performance-limiting factors. Some factors were a problem at many plants, while others occurred at only a few.

The performance-limiting factors were grouped into two categories: design/equipment and operation. *Operation factors cover the operation,* management, and maintenance practices at a plant; these can usually be eliminated at a relatively low cost. Design/equipment factors include design flaws and missing, damaged, or inaccurate equipment and instrumentation. These factors can be low or high cost items depending on the situation.

2.2 Most Common Factors

Figure 1 presents the 32 performance-limiting factors and shows how frequently they were encountered in the WPOS. The most frequently encountered factors are discussed in greater detail below, along with other factors which tend to affect small systems. To aid discussion of the occurrence of these factors with respect to plant capacity, the 44 plants were divided into five groups: 0-10 million litres per day (ML/d) (9 plants), 10-50 ML/d (9 plants), 50-100 ML/d (9 plants),

Figure 1. Performance-Limiting Factors at the 44 WPOS Supplies



* not dealt with in WPOS studies, but recognized by MOEE as a major factor

100-250 ML/d (9 plants), and greater than 250 ML/d (8 plants). Graphs showing how often the factors occurred at the various sizes of plants are in Appendix I.

2.2.1 Flow Measurement

Problems with flow measurement were identified at 61 percent of the 44 supplies. Plants where measuring devices were in need of calibration, or where adequate flowrate measurement (ie. raw and treated in conventional plants) was not provided, were deemed to have a problem. These problems were most prevalent at small water supply systems, where 15 of the 18 plants with capacity less than 50 ML/d were affected. Conversely, the largest plants were least affected; only 2 of the 8 plants larger than 250 ML/d had flow measurement problems. Flow measurement was a significant problem in small systems.

2.2.2 Chemical Selection and Application

Selection and application of treatment chemicals was identified as a problem in 55 percent of the 44 plants. Examples include: not selecting the optimum chemical for a specific job; errors in the preparation (ie. dilution, aging) of chemicals; and applying chemicals at the wrong point in the process (ie. not in the correct sequence or not allowing adequate retention time for chemicals to react). These problems affected systems of all sizes.

2.2.3 Turbidity Monitoring

Turbidity monitoring was a problem in 50 percent of the 44 plants. Plants not equipped with continuous turbidity monitoring of raw water, treated water and individual filter effluents, or where existing instrumentation was out of calibration or not in use, were deemed to have problems. Turbidity monitoring is quite adequate at most of the water supplies larger than 250 ML/d. However, the problem affected over 50 percent of the remaining supplies.

2.2.4 Filter Operation

Problems with filter operation were encountered at 45 percent of the 44 plants. Most problems pertained to backwashing; examples include no criteria for initiating backwash, no optimization of backwash rates and durations, and not investigating alternative modes of operation. This problem affected nearly all of the smallest systems.

2.2.5 Chemical Mixing

Chemical mixing was a problem at 41 percent of the 44 plants. The most common problem was insufficient or absent rapid mixing and slow mixing for coagulants. Larger plants had more problems with mixing than smaller systems.

2.2.6 Control of Chemical Feeds and Dosages

The control of chemical feeds and dosages was identified as a problem at 41 percent of the 44 supplies. Examples of problems encountered include the absence of flow pacing or additional levels of control when required, and no means of calibrating feed pumps. Poor control prevents the plant from producing the best possible water quality and impairs the plant's ability to handle changes in raw water quality. The control of chemical feed and dosages was a significant problem in small systems.

2.2.7 Plant Hydraulics

Plant hydraulics had an effect on the performance of 39 percent of the 44 supplies. Examples include overloading, bottlenecks and unequal flow splits in the treatment train, and short circuiting in tankage. These problems cause upsets in unit processes and can limit the potential output of a plant. This problem occurred in plants of all sizes, although the smallest plants were not affected as often. This was expected because

some smaller plants were pre-engineered package plants with proven designs.

2.2.8 Record Keeping and Data Management

Record keeping and data management was a problem at 36 percent of the 44 supplies. This includes incomplete or inaccurate recording of water quality parameters, operations data and complaints, as well as a lack of computer facilities that would facilitate efficient and organized storage and reporting of information. There was little correlation between occurrence of this factor and plant capacity.

2.2.9 Process Testing

The amount of process testing conducted by operators was a problem at 32 percent of the 44 plants. The degree to which operators conducted bench-scale (ie. jar tests) and plant-scale testing in order to optimize aspects of their treatment had a significant impact on plant performance. Operators who demonstrated curiosity and interest were able to utilize more of their plant's potential and have a better understanding of the process. There was little correlation between occurrence of this factor and plant capacity.

2.3 Factors Affecting Small Systems

In addition to several of the factors discussed above, there were other performance-limiting factors that affected small water supplies disproportionately.

2.3.1 Chlorine Residual Monitoring

Problems with chlorine residual monitoring affected 37 percent of plants that were 100 ML/d or less in size. Plants not equipped with on-line monitors were judged to have problems in this area. All plants larger than 100 ML/d were well-equipped for chlorine residual monitoring.

2.3.2 Alarm Capability

Insufficient alarm capability was a problem at 67 percent of plants that were 10 ML/d or less in size. These plants were not equipped with necessary alarms such as high turbidity or low chlorine residual alarms.

2.3.3 Start/Stop Operation

A start/stop mode of plant operation affected performance at 55 percent of plants that were 10 ML/d or less in size. These plants were adversely affected, especially in the filtration process, by hydraulic surges caused by the start/stop operation of pumps. Small systems may be designed without more sophisticated control for reasons of cost.

2.3.4 Upflow Clarifier Operation

The operation of upflow clarifiers was identified as a problem at 6 of the 11 plants that employed upflow clarification in their process. All these plants were less than 100 ML/d in capacity. Floc carryover is the main concern; these clarifiers are known to be more troublesome to operate than conventional flocculation and sedimentation basins.

2.3.5 Plant Flow Control

Control of flow through the plant was a concern at 55 percent of plants that were 10 ML/d or less in capacity. These plants must upgrade their pumps, valves, level sensors etc. in order to improve control of flow and pumping throughout the plant.

2.3.6 Operations Manual

No operations manual was found at 55 percent of plants that were 10 ML/d or less in capacity. An operations manual is important for staff training and as a reference.

2.3.7 Operator Expertise

Operator expertise was not specifically addressed by the WPOS consultants, therefore it was not identified as a problem at any supply. However, this is a major problem at many water plants, especially in smaller municipalities where there is little money to attract skilled operators or for training. Many operators are skilled in maintenance, but do not understand the fundamentals of water treatment in terms of the chemistry and the unit processes. Consequently, they are unable to optimize plant operation and have difficulty adapting to changes in raw water quality.

2.4 Conclusions

The initial goal of the WPOS was to document the facilities and conditions at each of the supplies being studied, and to determine an optimum treatment strategy at each of these supplies. This goal was achieved; studies were completed and reports published with short and long-term recommendations for achieving optimum plant performance.

Experience has shown that studies are most effectively conducted by consulting engineers who are process specialists. It was also important to have the study actively managed by a project committee to ensure adherence to the terms of reference and the principles of water plant optimization. The cost for an optimization study, excluding followup technical assistance, was in the $20k to $40k range.

A second goal of the WPOS was to look at the 44-plant study as a whole and identify the problems faced by water utilities. An examination of the consultants' recommendations has led to the identification of key operational and design/ equipment-related factors that limit plant performance. The most common problem areas were: flow measurement; selection, preparation and application of treatment chemicals; turbidity monitoring; filter operation; chemical mixing; control

of chemical feeds and dosages; plant hydraulics; record keeping and data management; and process testing. It should be recognized that many of these problem areas are of fundamental importance, and thus it is possible to greatly improve plant performance by addressing these problems in an optimization plan.

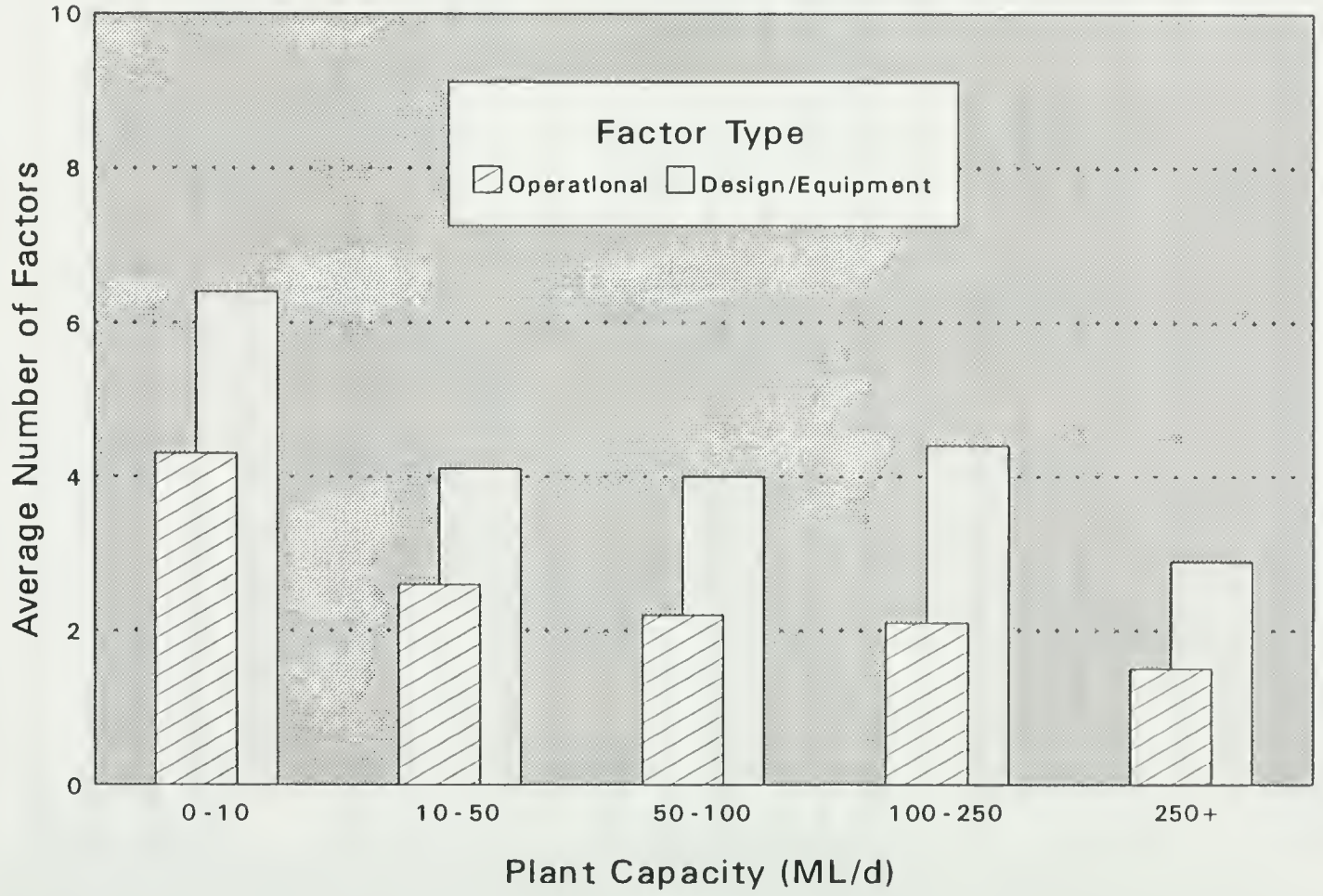
Small water supplies had more physical and operational deficiencies than larger plants. Figure 2 shows that plants in the 0-10 ML/d capacity range had twice as many problems as larger plants. The largest plants (in the over 250 ML/d range) had the fewest problems. Small water supplies are disproportionately affected by the following problems: flow measurement; selection, preparation and application of treatment chemicals; filter operation; control of chemical feeds and dosages; chlorine residual monitoring; alarm capability; start/stop operation; up-flow clarifier operation; control of plant flow; no operations manual; inspection and maintenance and operator expertise. Some of these problems are related to the lack of resources in small municipalities for essential equipment and operator training. Other problems, such as start/stop operation and operation of up-flow clarifiers, are related to the design characteristics of many small water plants.

2.5 Future Directions

The present goal of the MOEE is to institutionalize water plant optimization in Ontario to the point where it can take place with only minor MOEE involvement. This will be done by implementing several actions.

All municipalities applying to the Province for funding of water and sewage infrastructure will be required by 1996 to conduct system optimization and water efficiency studies in order to be considered for funding. System optimization has now become an integral part of Ontario's water and sewage infrastructure planning.

Figure 2. Average Number of Performance-Limiting Factors
Present at Plants in these Capacity Ranges



The MOEE is presently working to develop revised protocols for water plant optimization based on experience gained in the WPOS and on the USEPA's Composite Correction Program (CCP). The CCP has been applied successfully to the optimization of water treatment plants in several U.S. states.

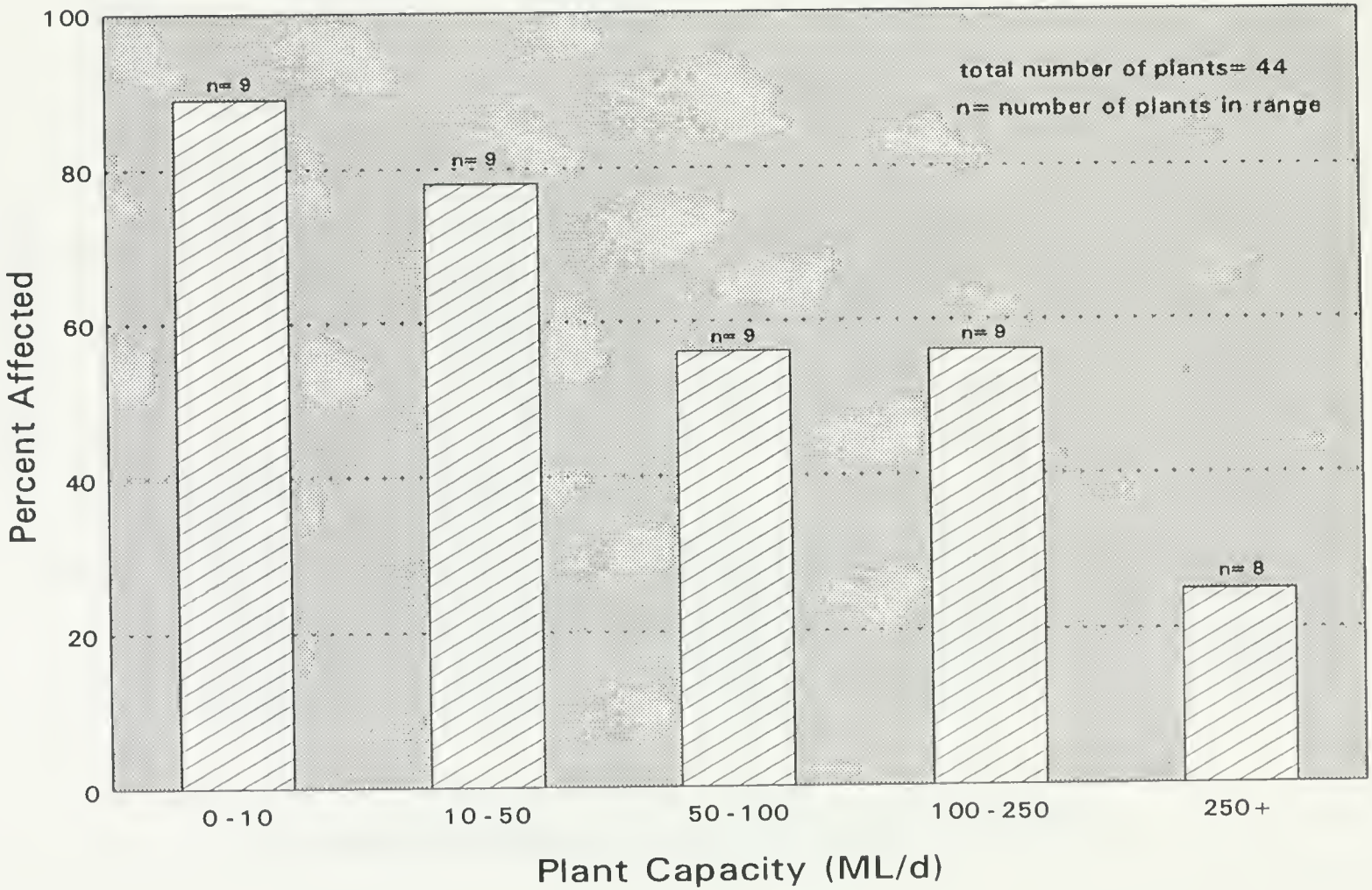
The MOEE will conduct pilot optimization studies to build experience and confidence with the revised protocols. Knowledge will be transferred to consulting engineers and utilities through joint participation in pilot optimization studies and seminars.

APPENDIX I

OCCURRENCE OF THE 32 PERFORMANCE-LIMITING FACTORS AT THE 44 WPOS SUPPLIES

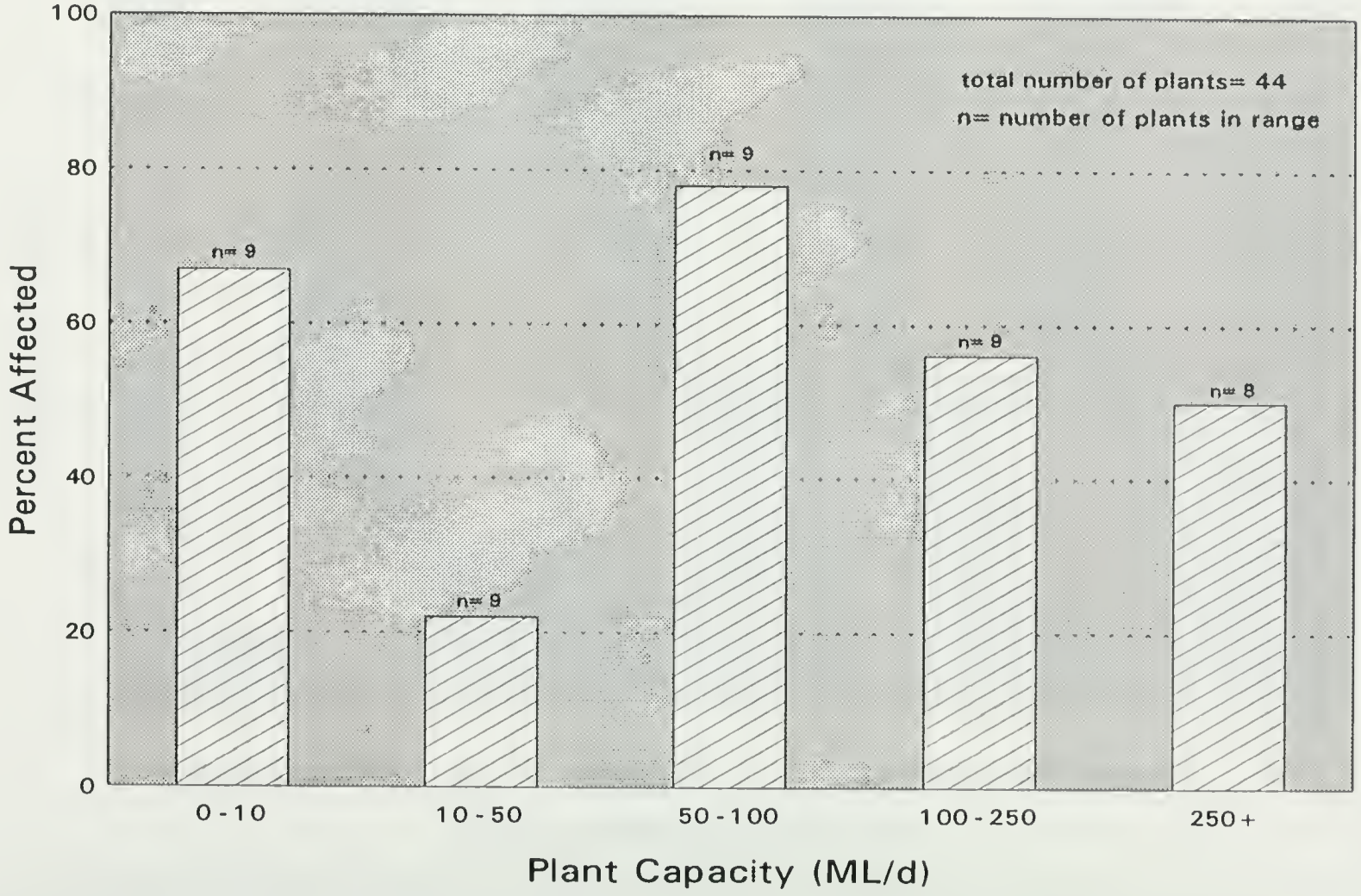
Flow Measurement

Percentage of Plants Affected in Given Capacity Range



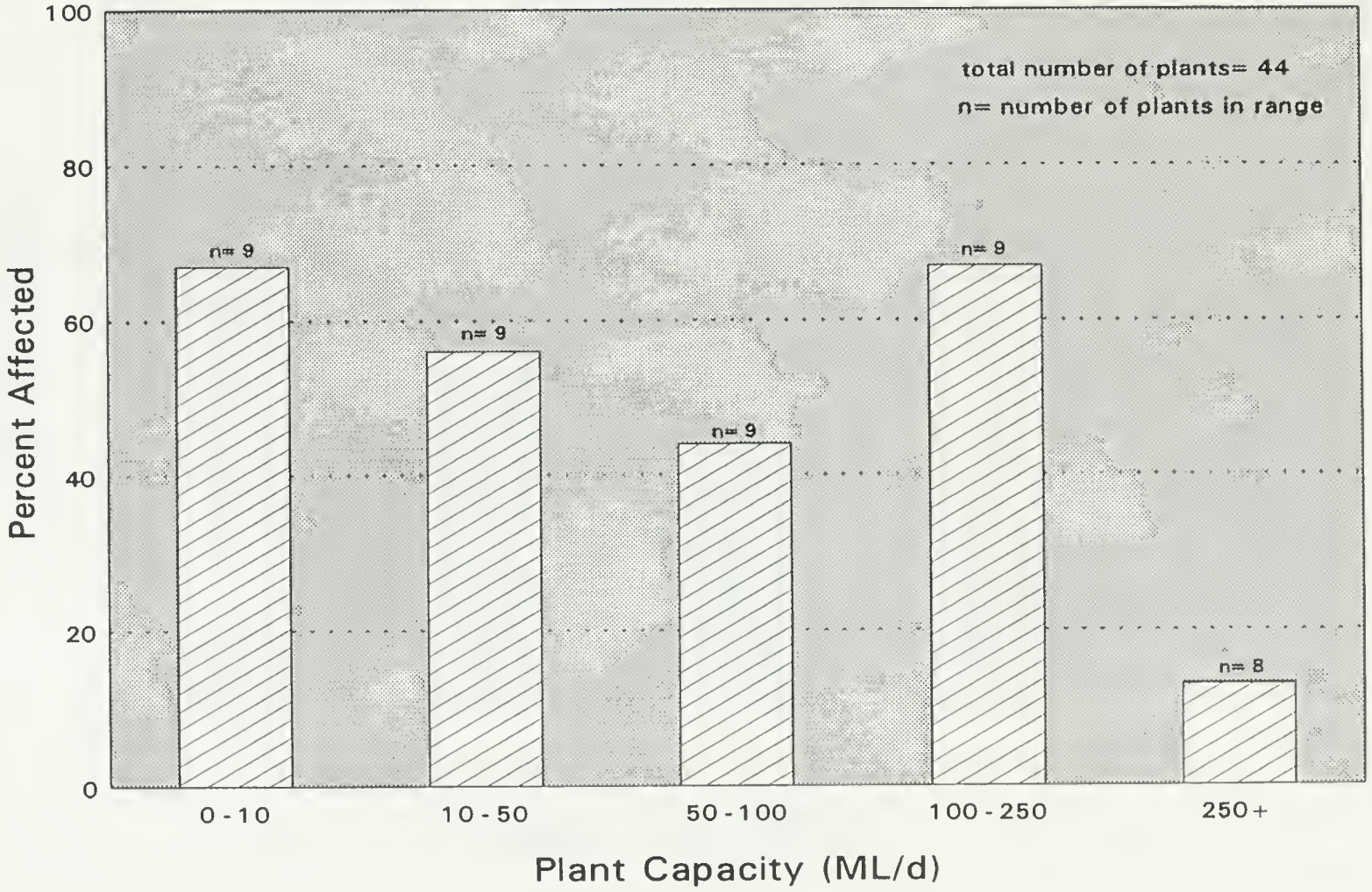
Chemical Selection and Application

Percentage of Plants Affected in Given Capacity Range



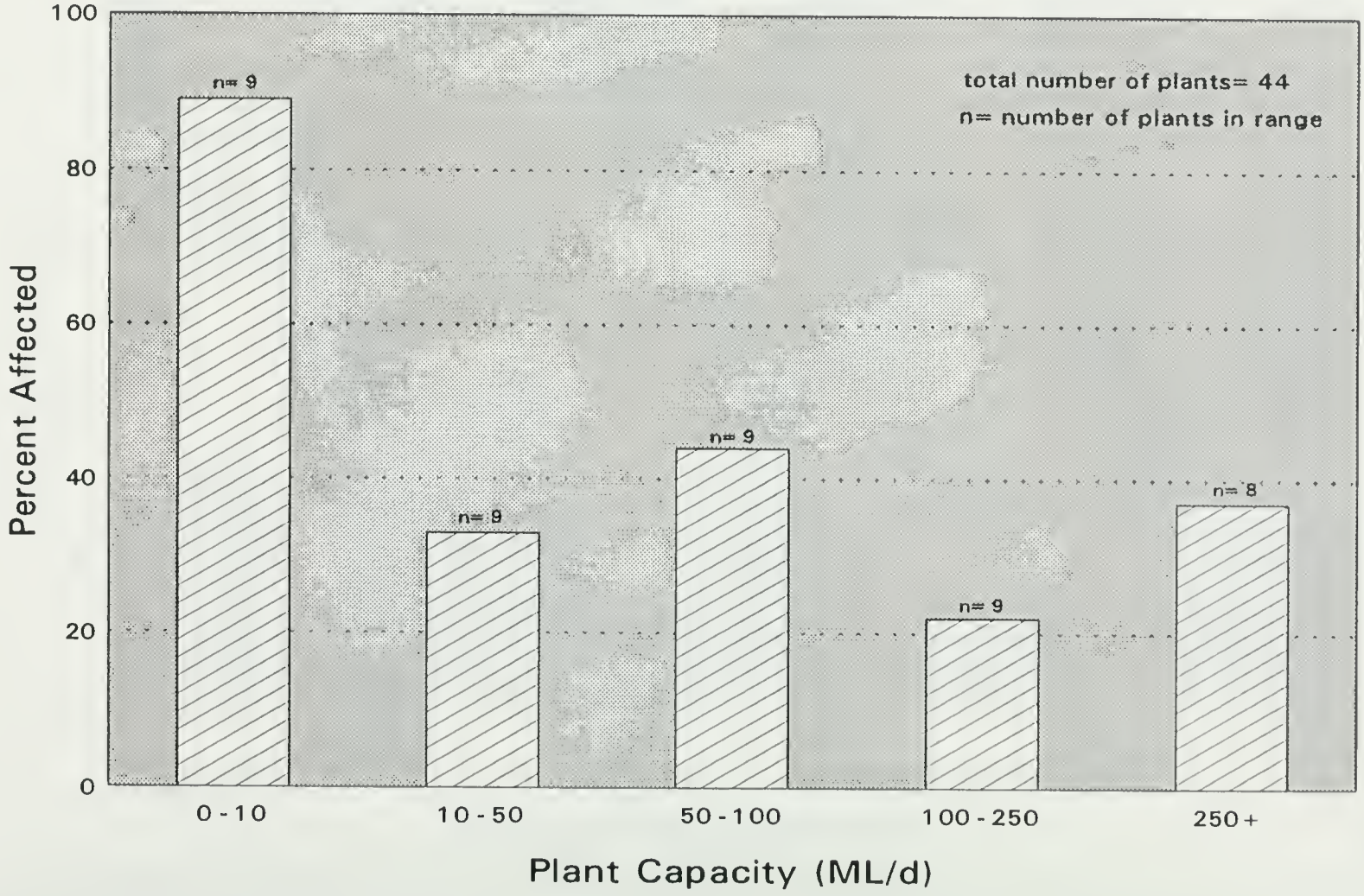
Turbidity Monitoring

Percentage of Plants Affected in Given Capacity Range



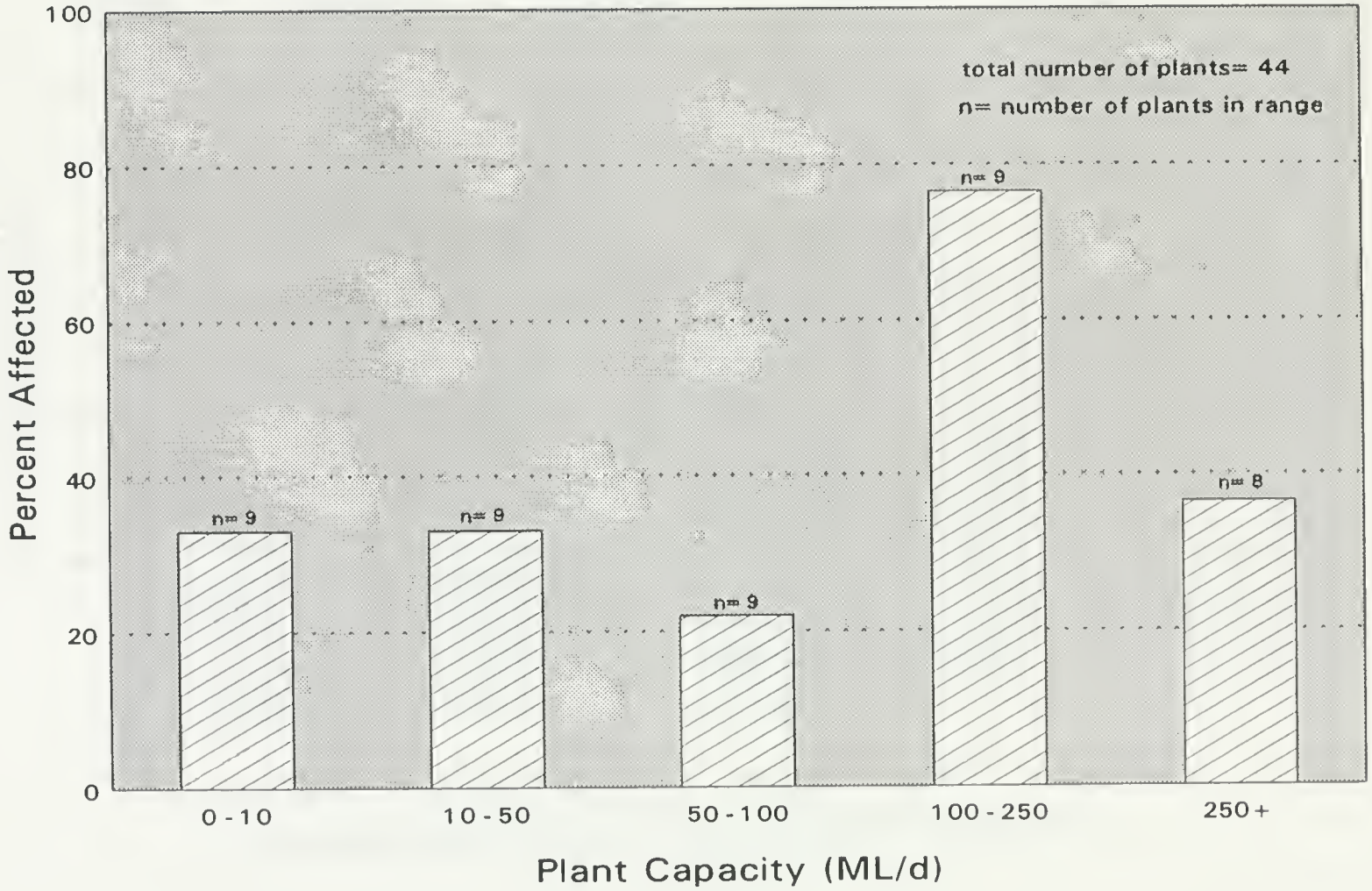
Filter Operation

Percentage of Plants Affected in Given Capacity Range



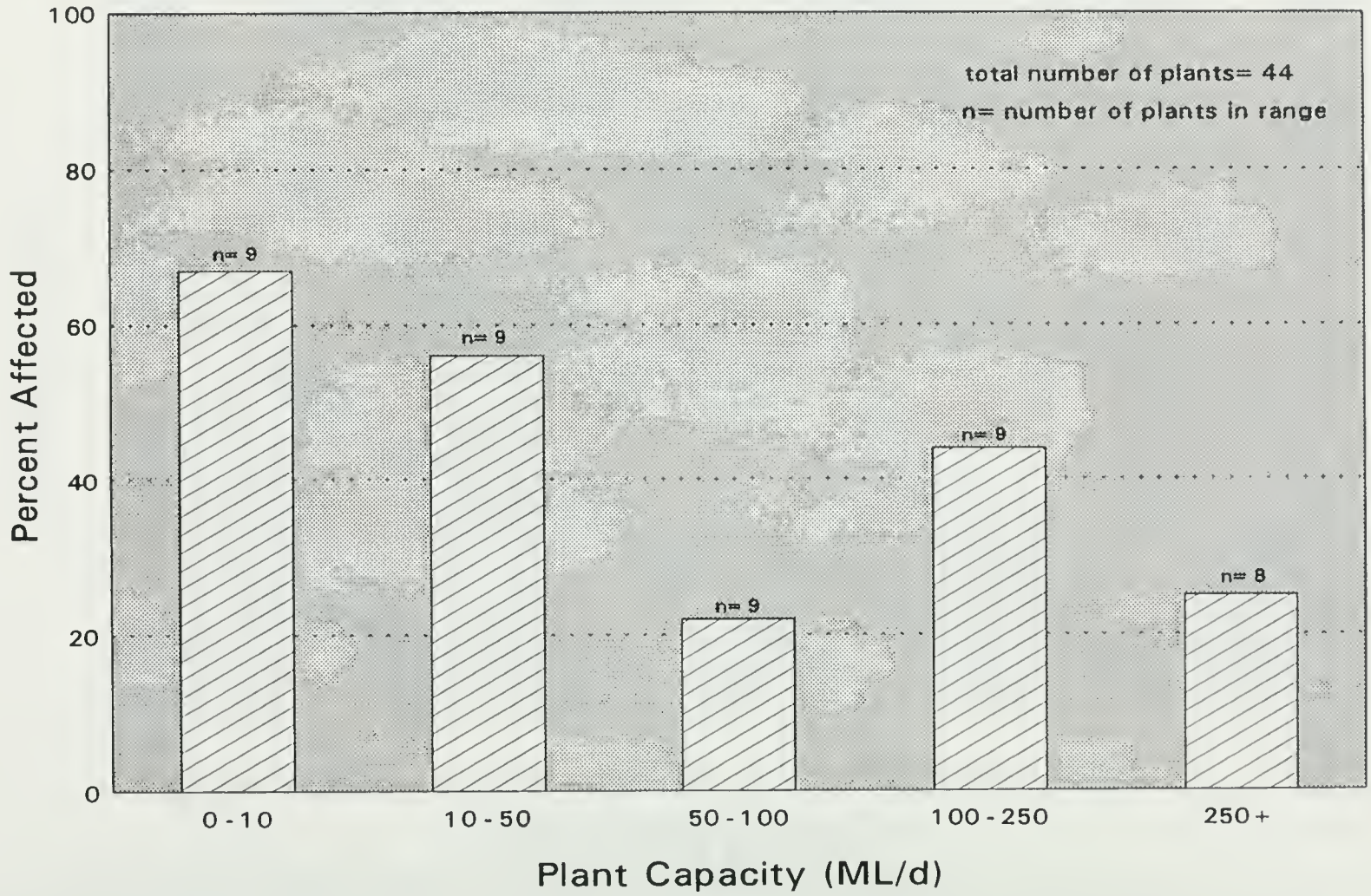
Chemical Mixing

Percentage of Plants Affected in Given Capacity Range



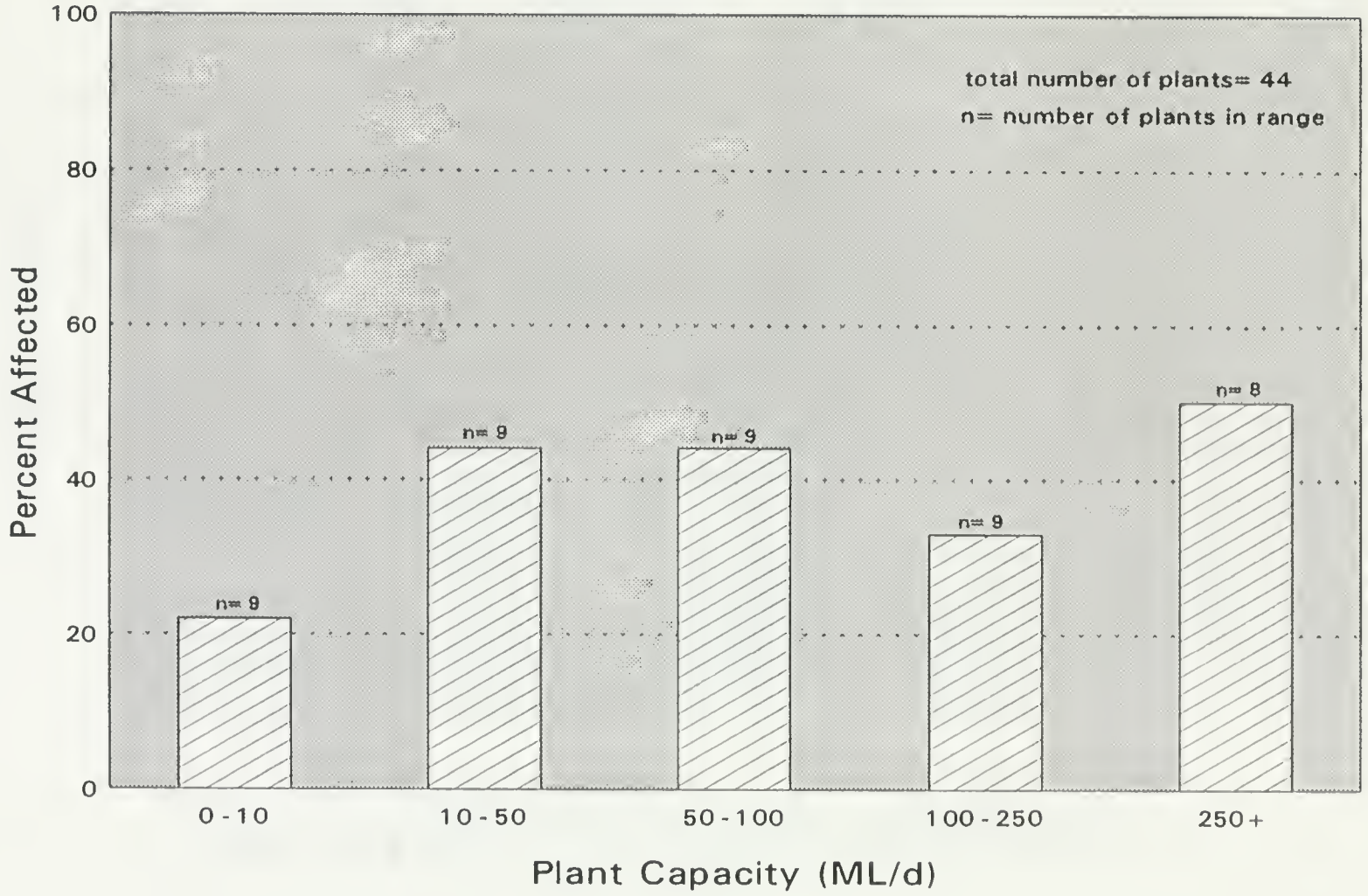
Chemical Feed and Dosage Control

Percentage of Plants Affected in Given Capacity Range



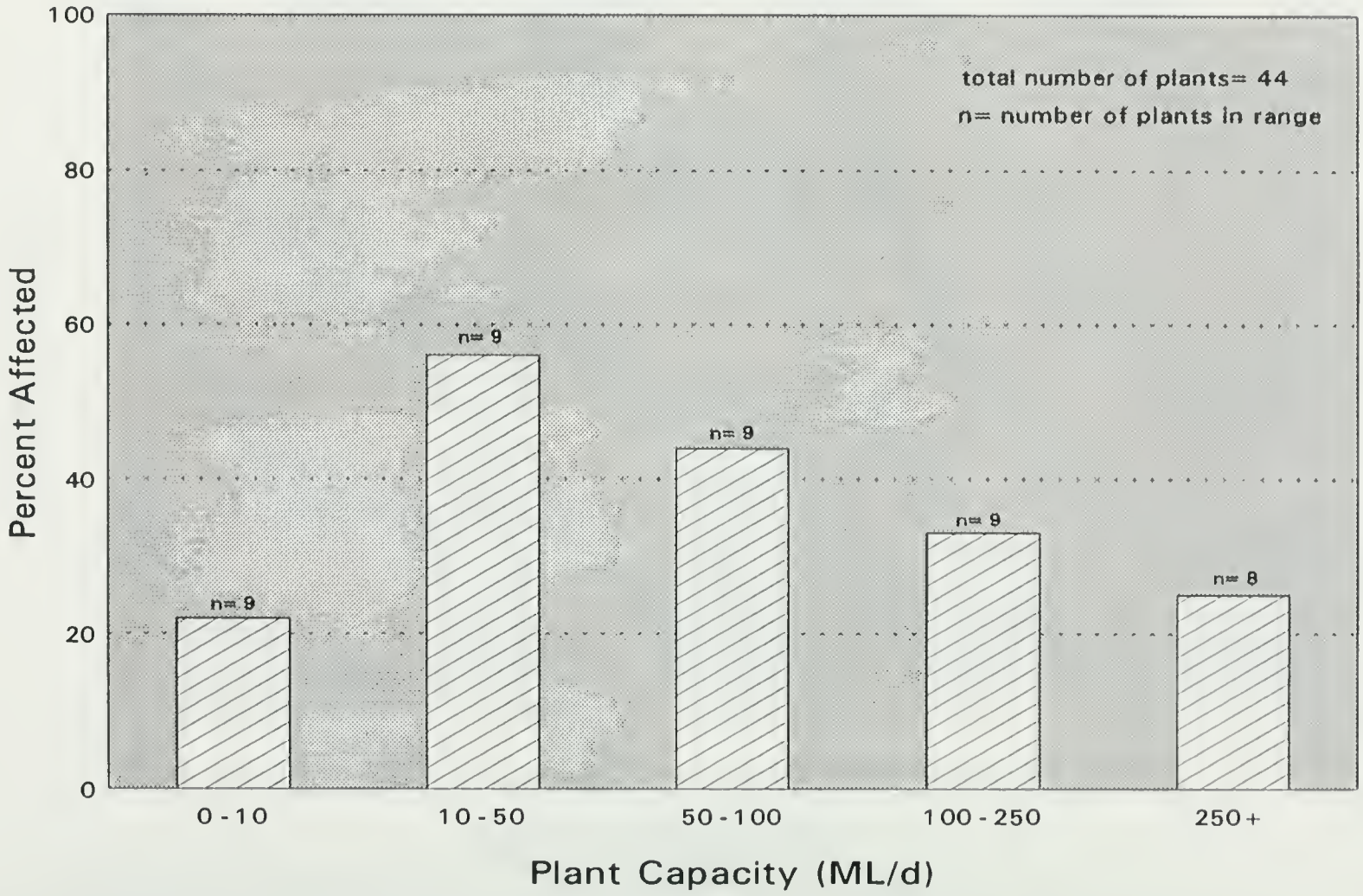
Plant Hydraulics

Percentage of Plants Affected in Given Capacity Range



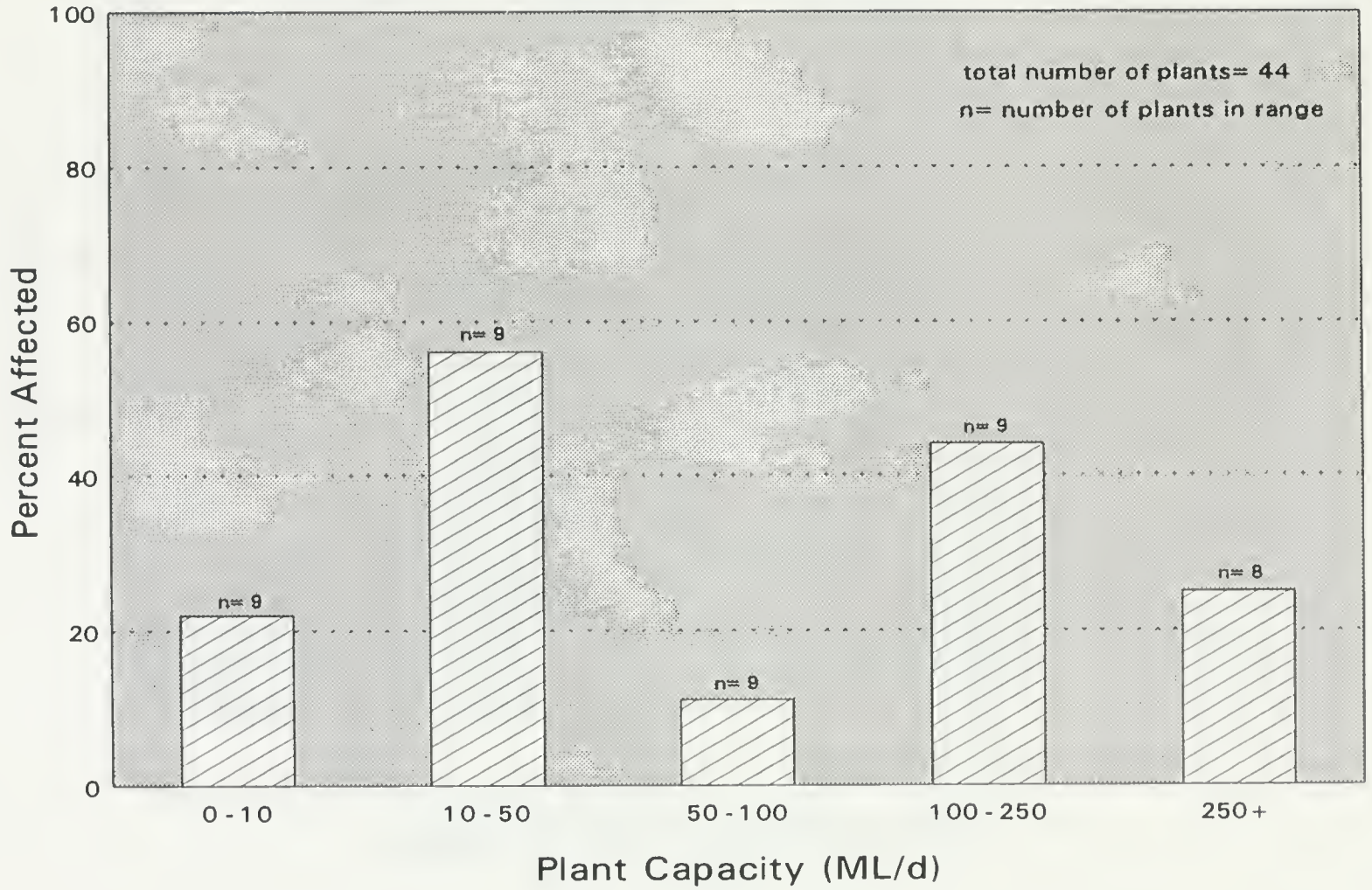
Record Keeping and Data Management

Percentage of Plants Affected in Given Capacity Range



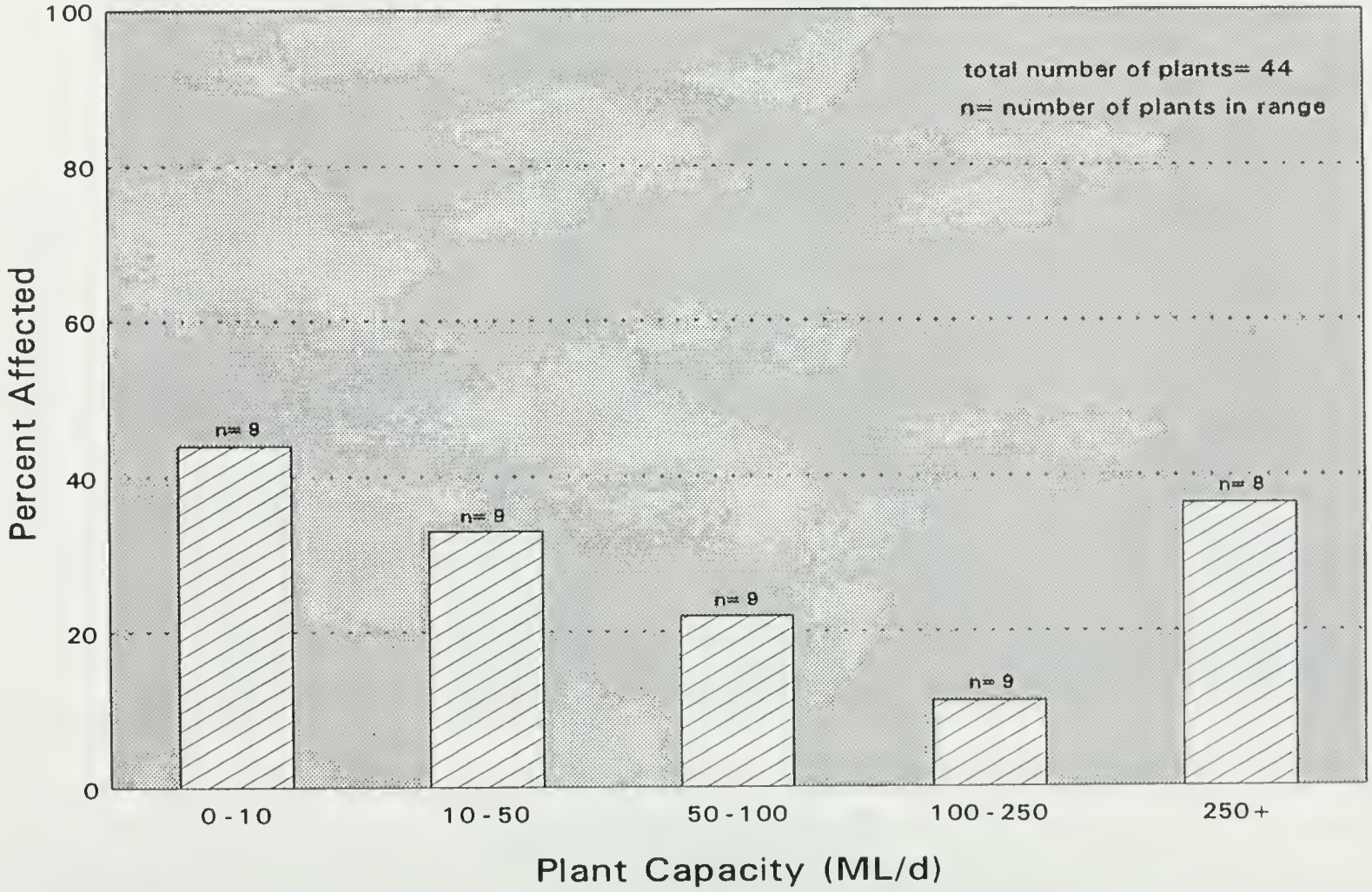
Process Testing

Percentage of Plants Affected in Given Capacity Range



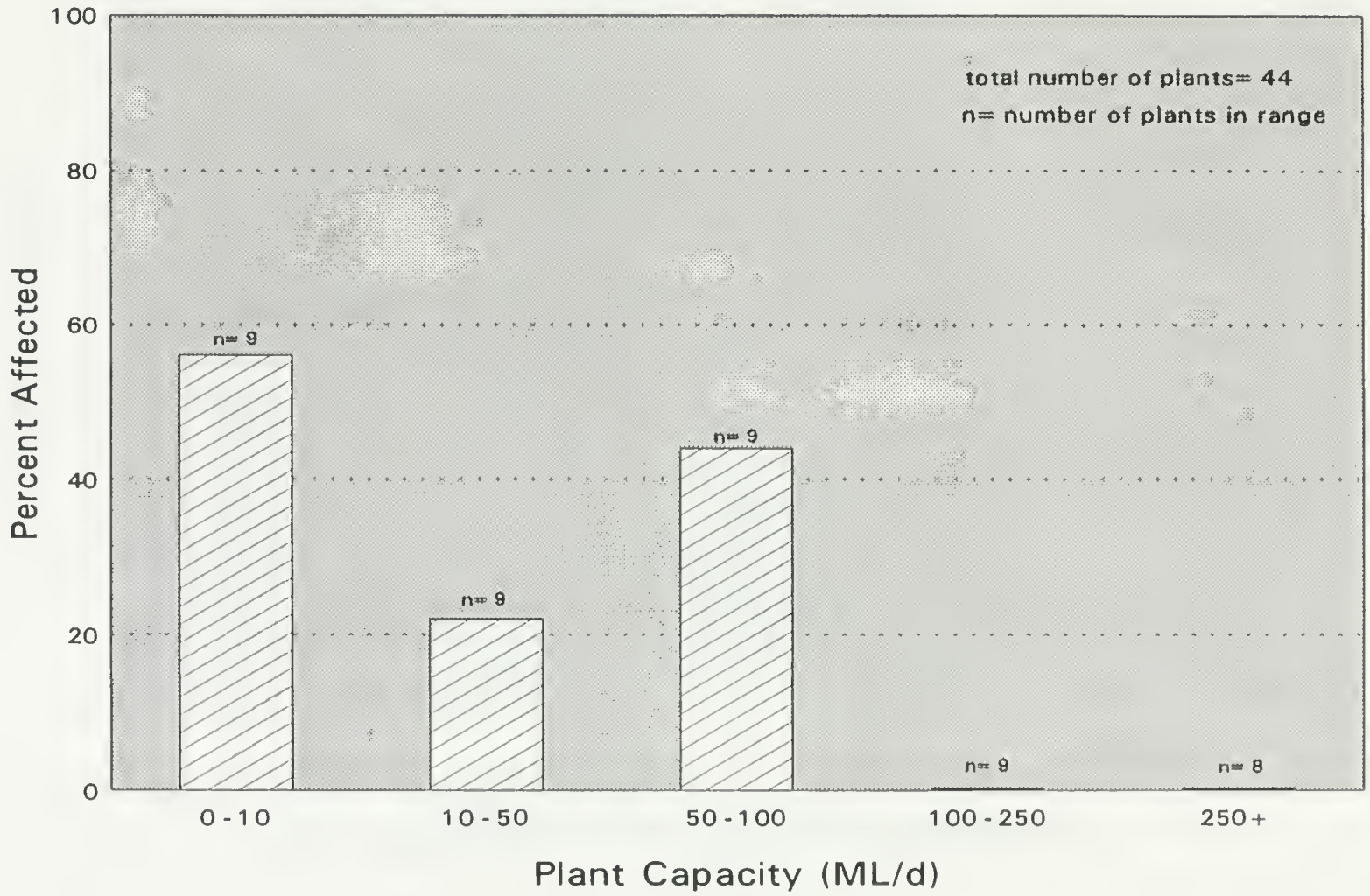
Water Quality Monitoring

Percentage of Plants Affected in Given Capacity Range



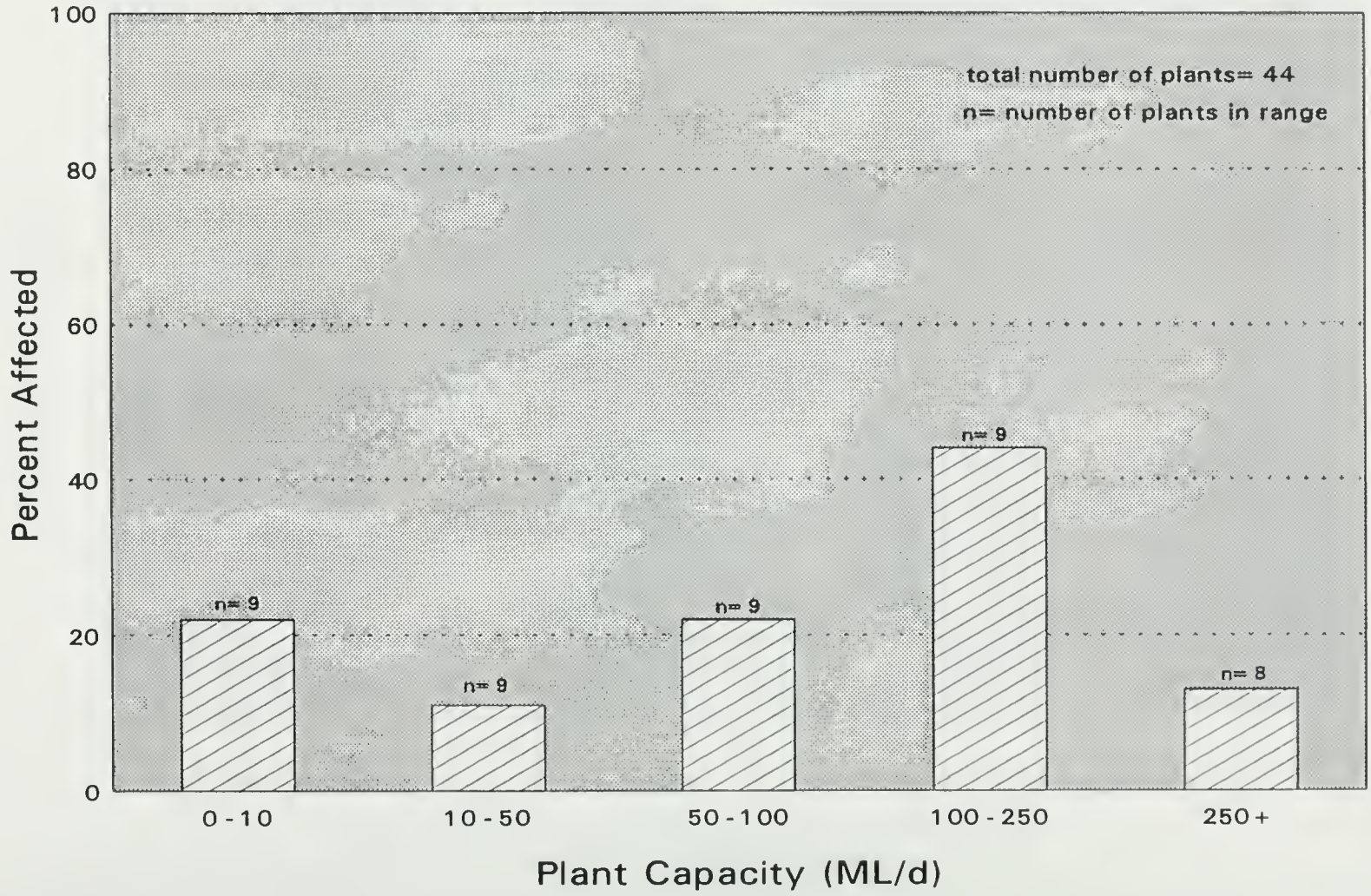
Chlorine Residual Monitoring

Percentage of Plants Affected in Given Capacity Range



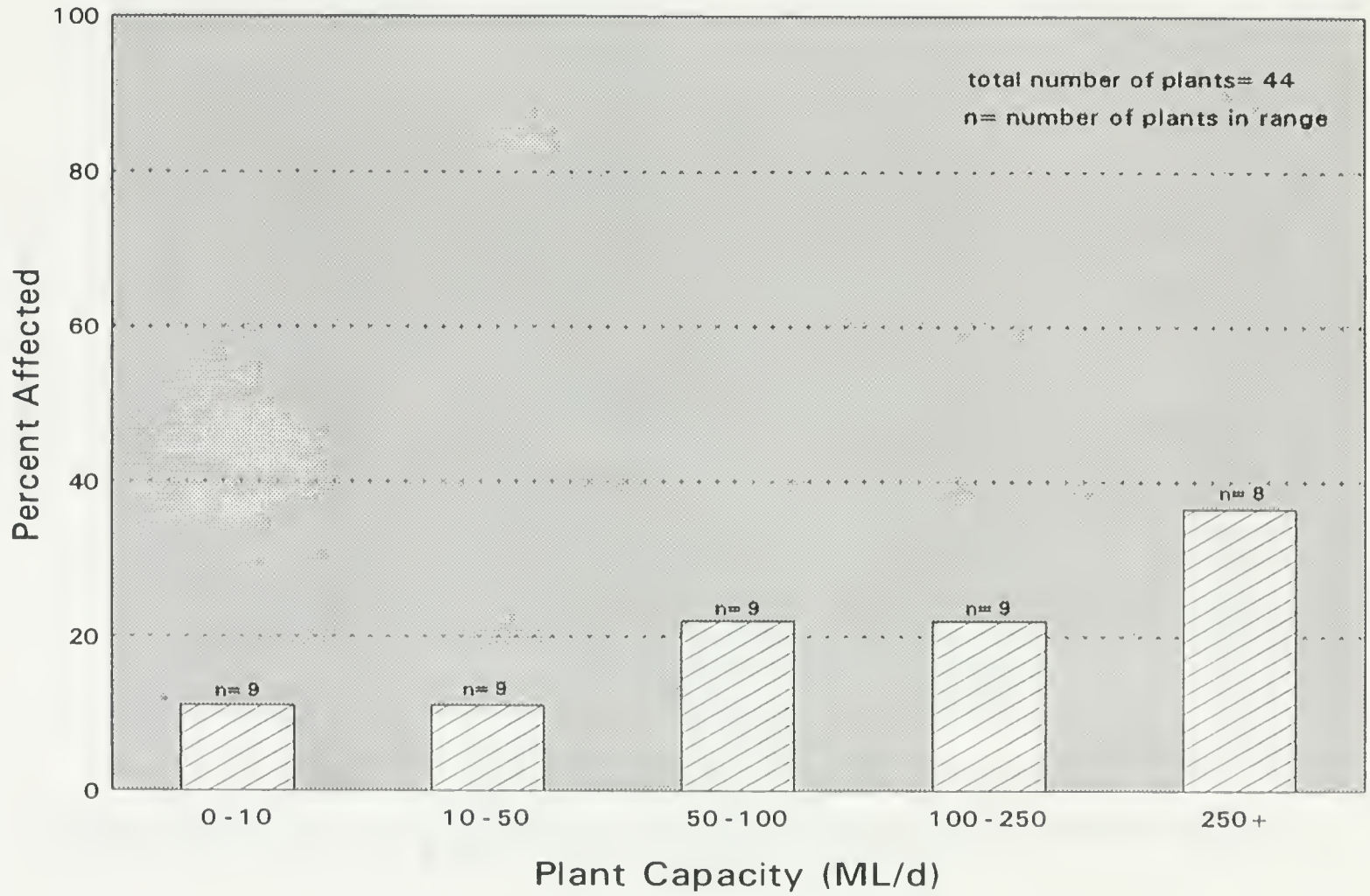
No Process and Piping Diagram

Percentage of Plants Affected in Given Capacity Range



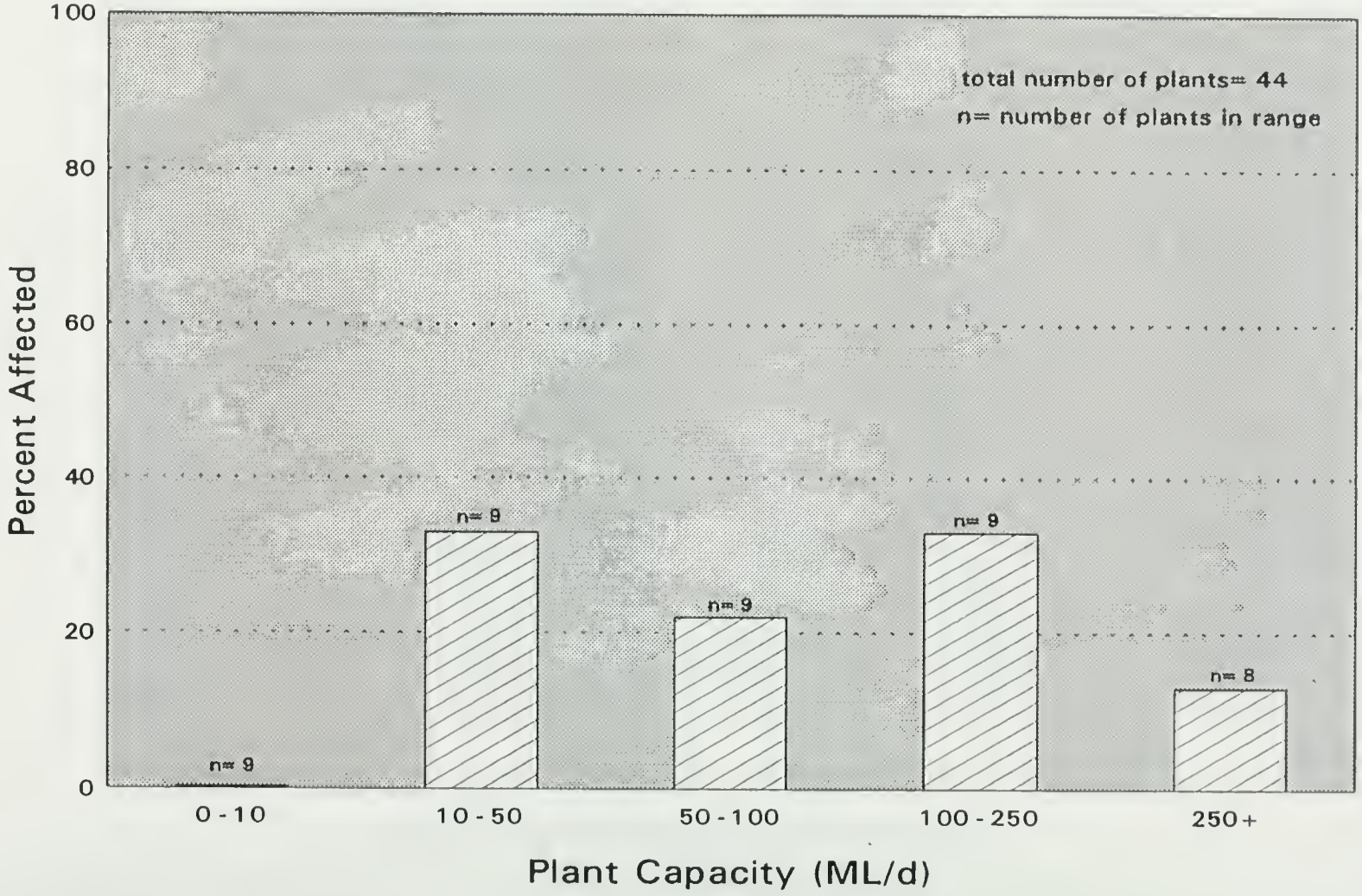
Plant Sampling Systems

Percentage of Plants Affected in Given Capacity Range



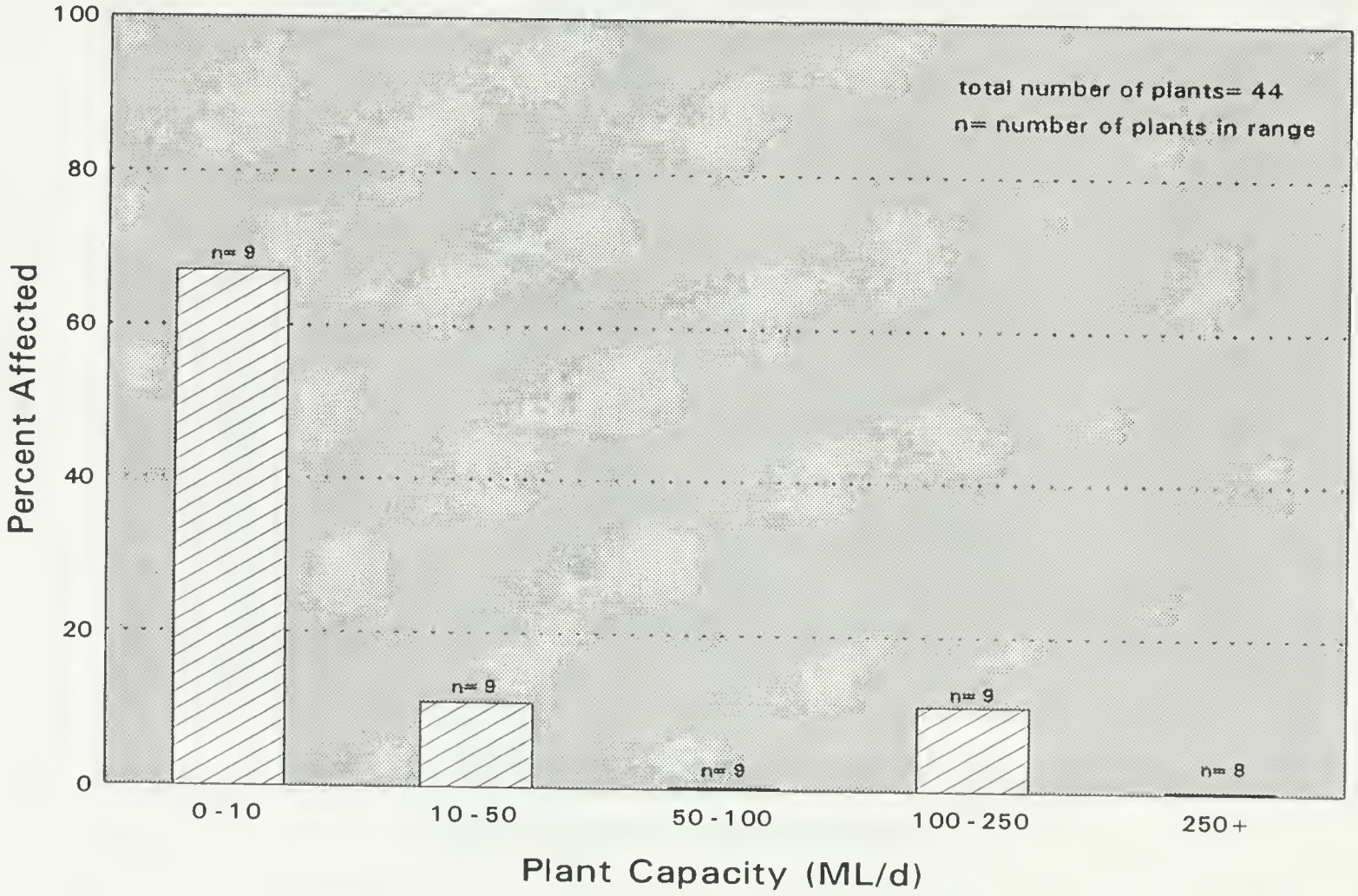
Measurement of Pre and Post Chlorine Consumption

Percentage of Plants Affected in Given Capacity Range



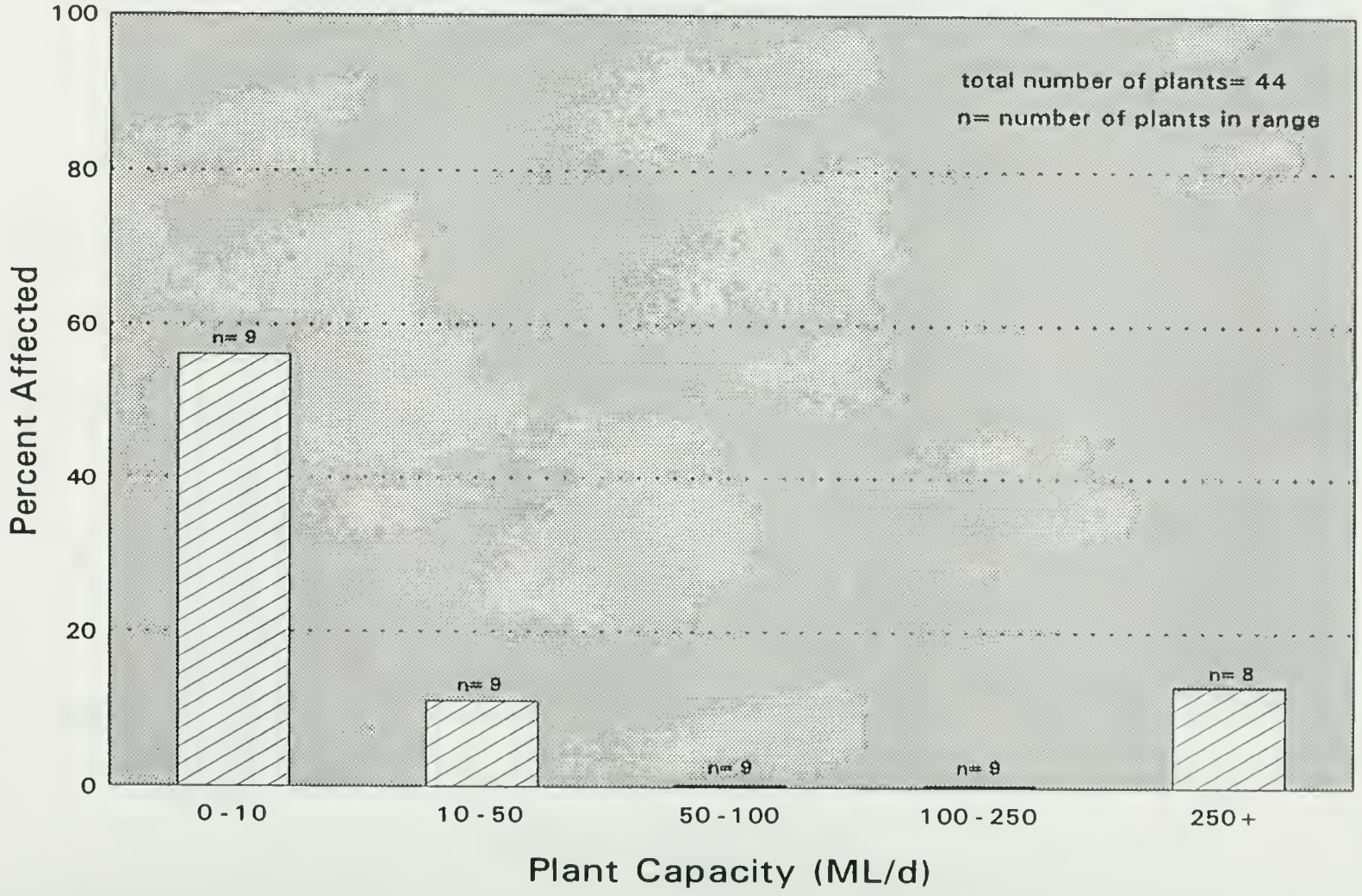
Alarm Capability

Percentage of Plants Affected in Given Capacity Range



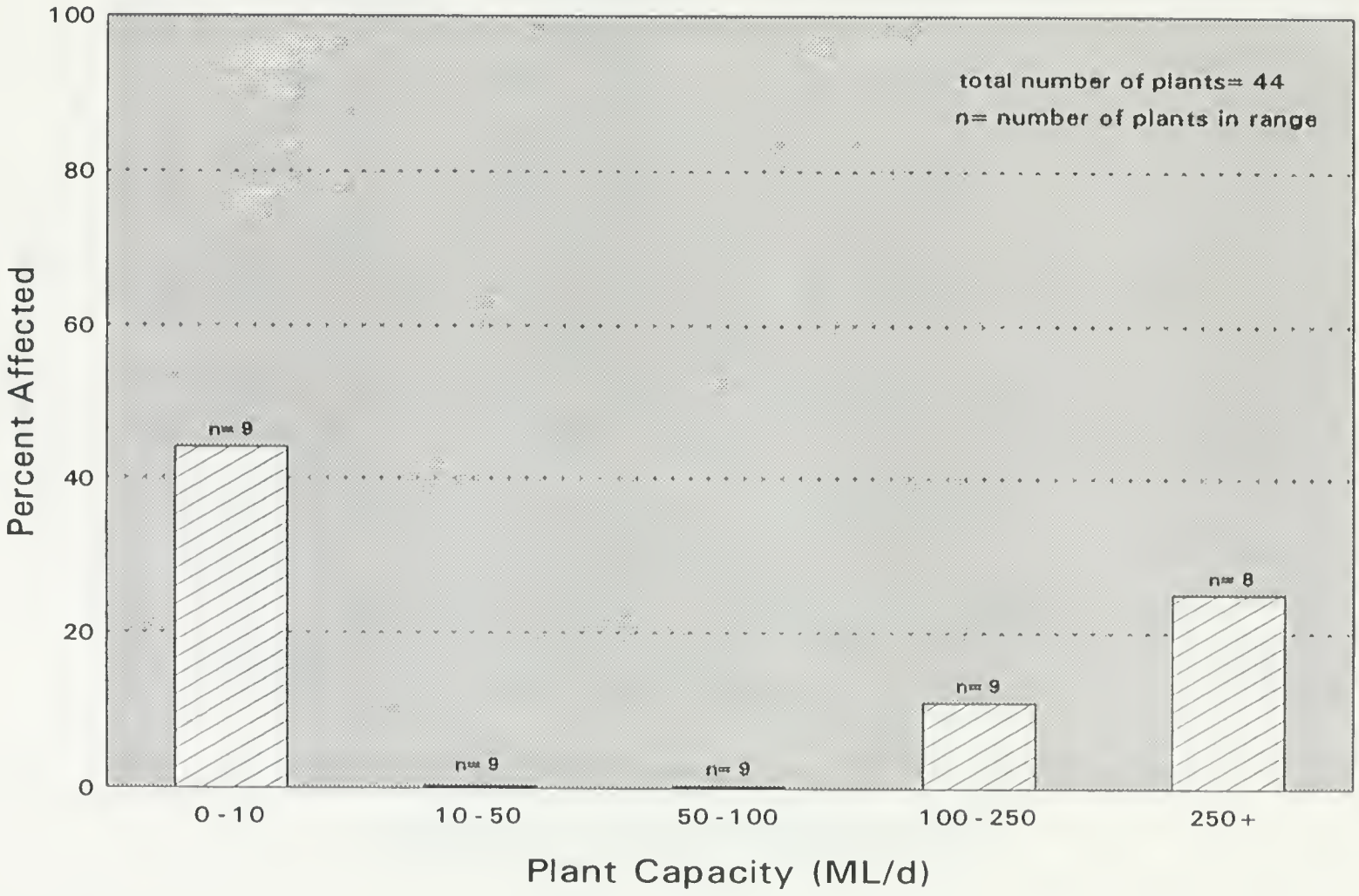
Start/Stop Operation

Percentage of Plants Affected in Given Capacity Range



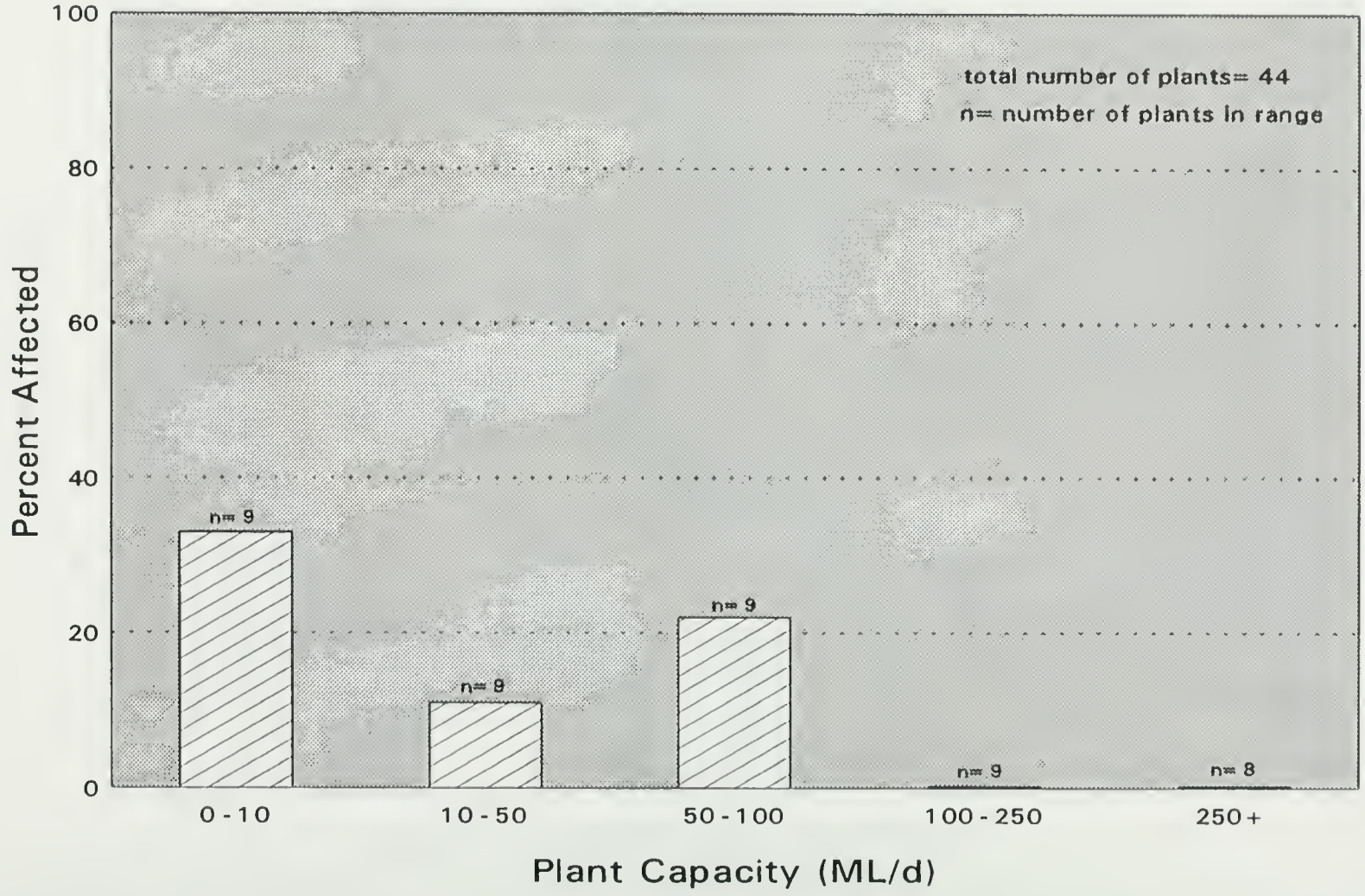
Filter Design and Control

Percentage of Plants Affected in Given Capacity Range



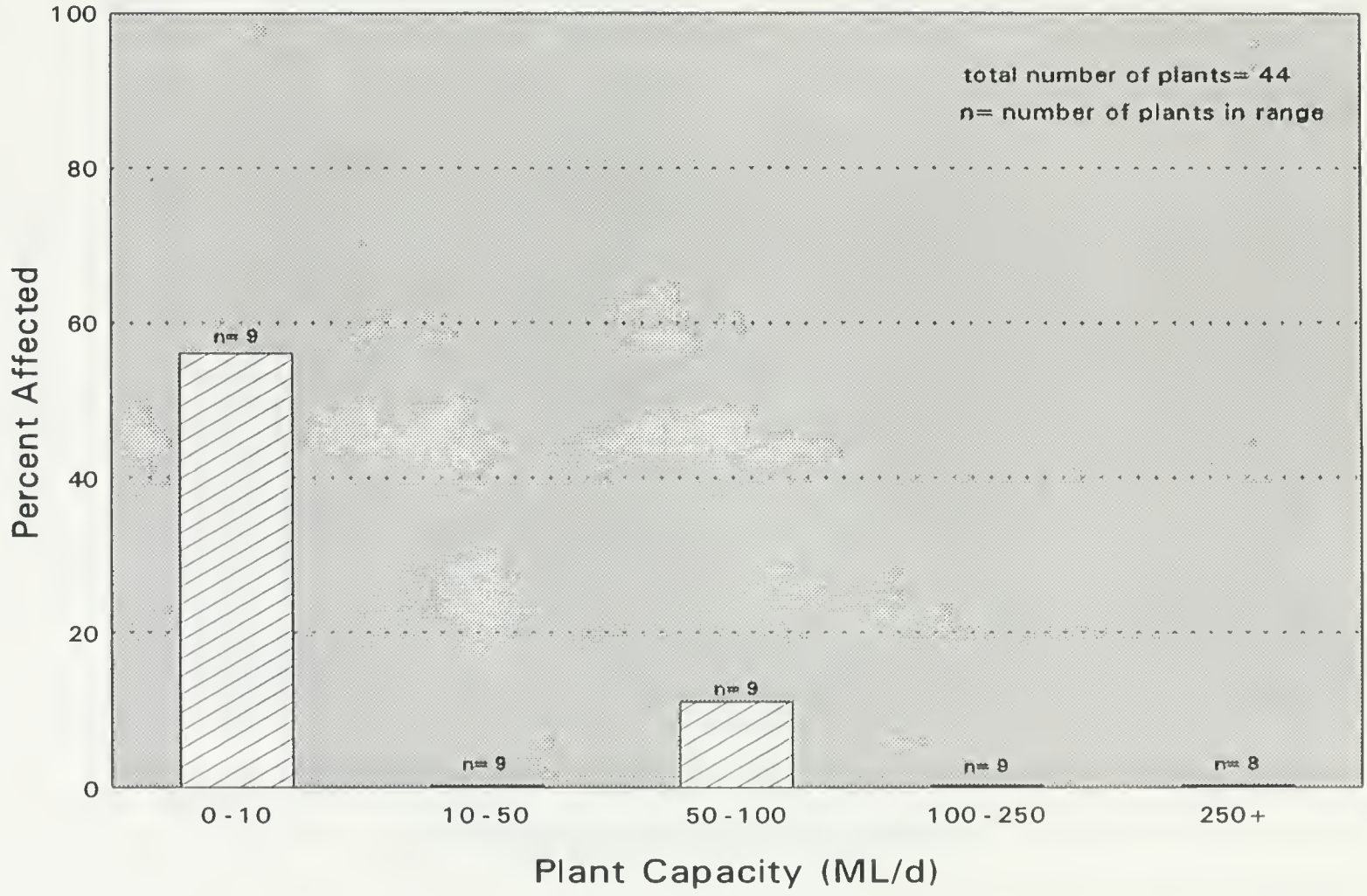
Upflow Clarifier Operation

Percentage of Plants Affected in Given Capacity Range



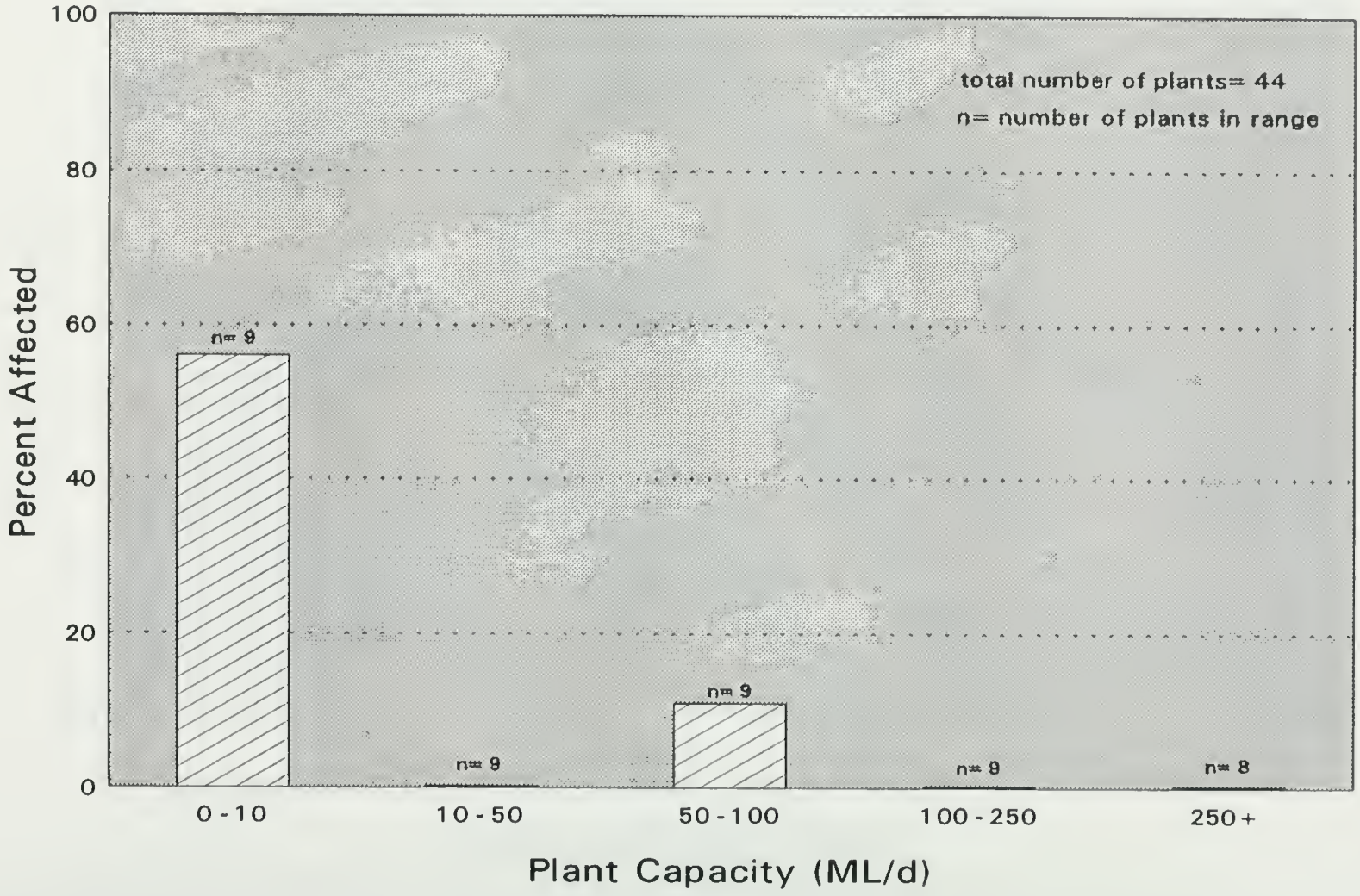
Plant Flow Control

Percentage of Plants Affected in Given Capacity Range



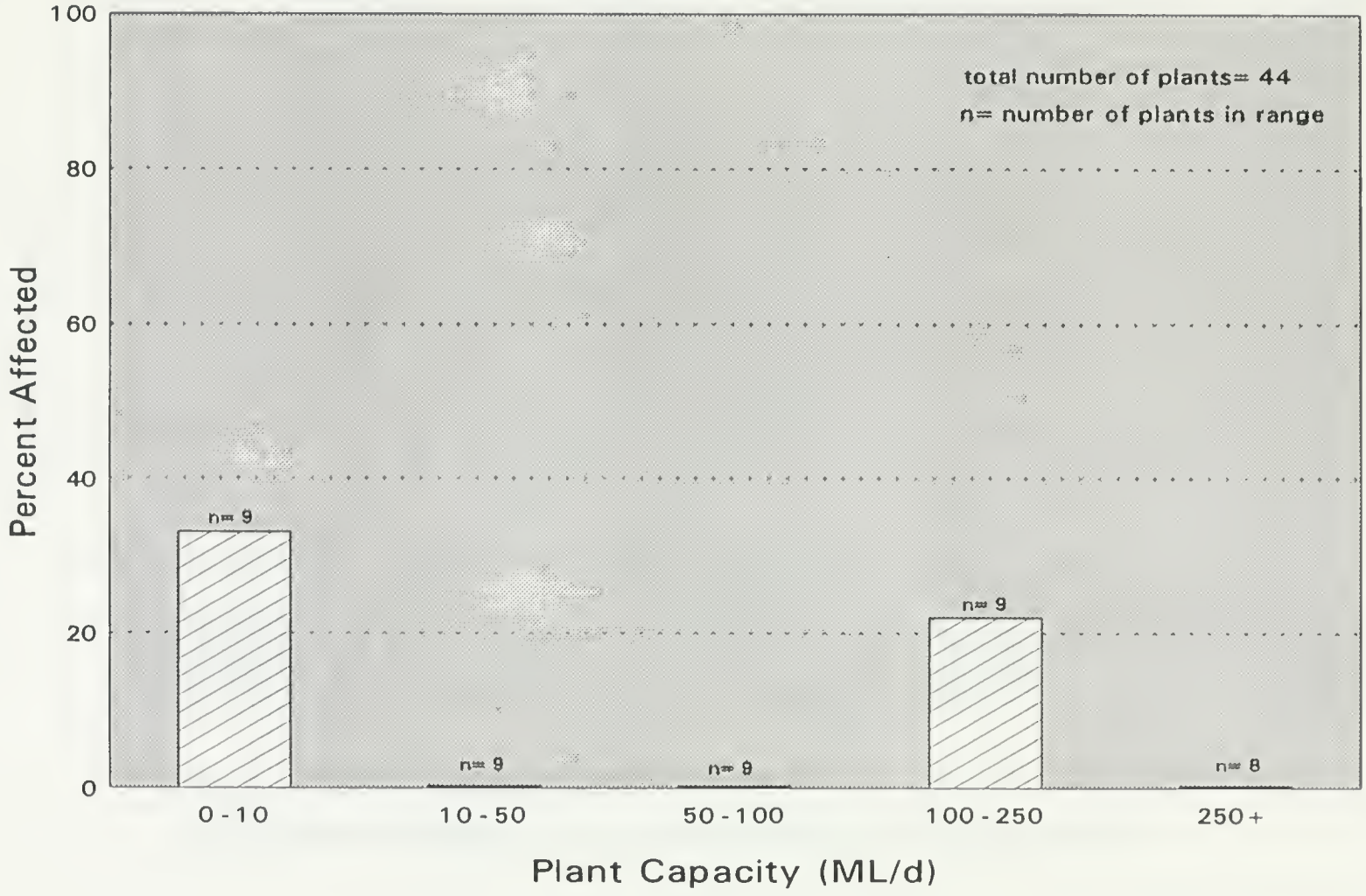
No Operations Manual

Percentage of Plants Affected in Given Capacity Range



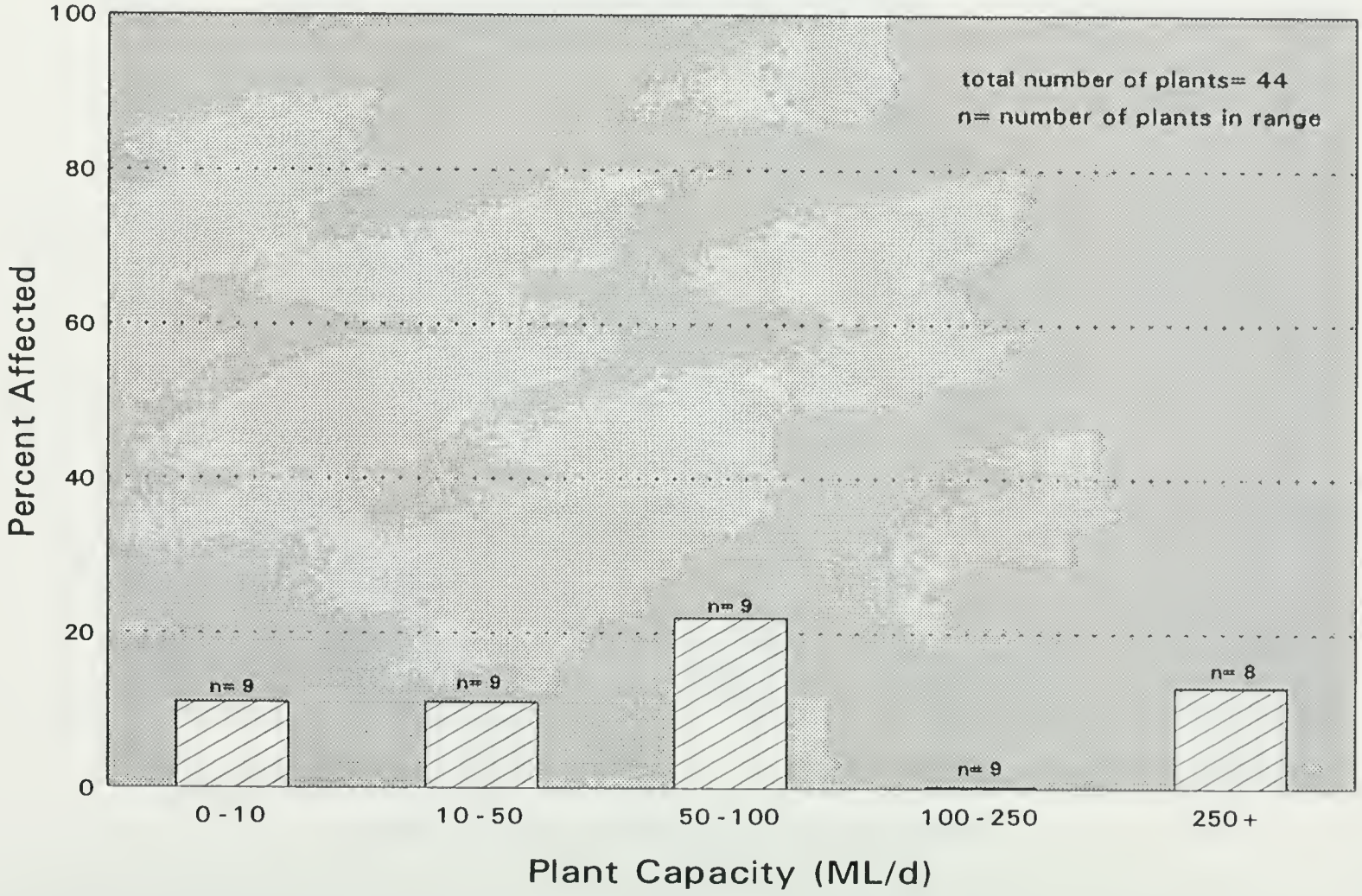
Plant Laboratory Facilities

Percentage of Plants Affected in Given Capacity Range



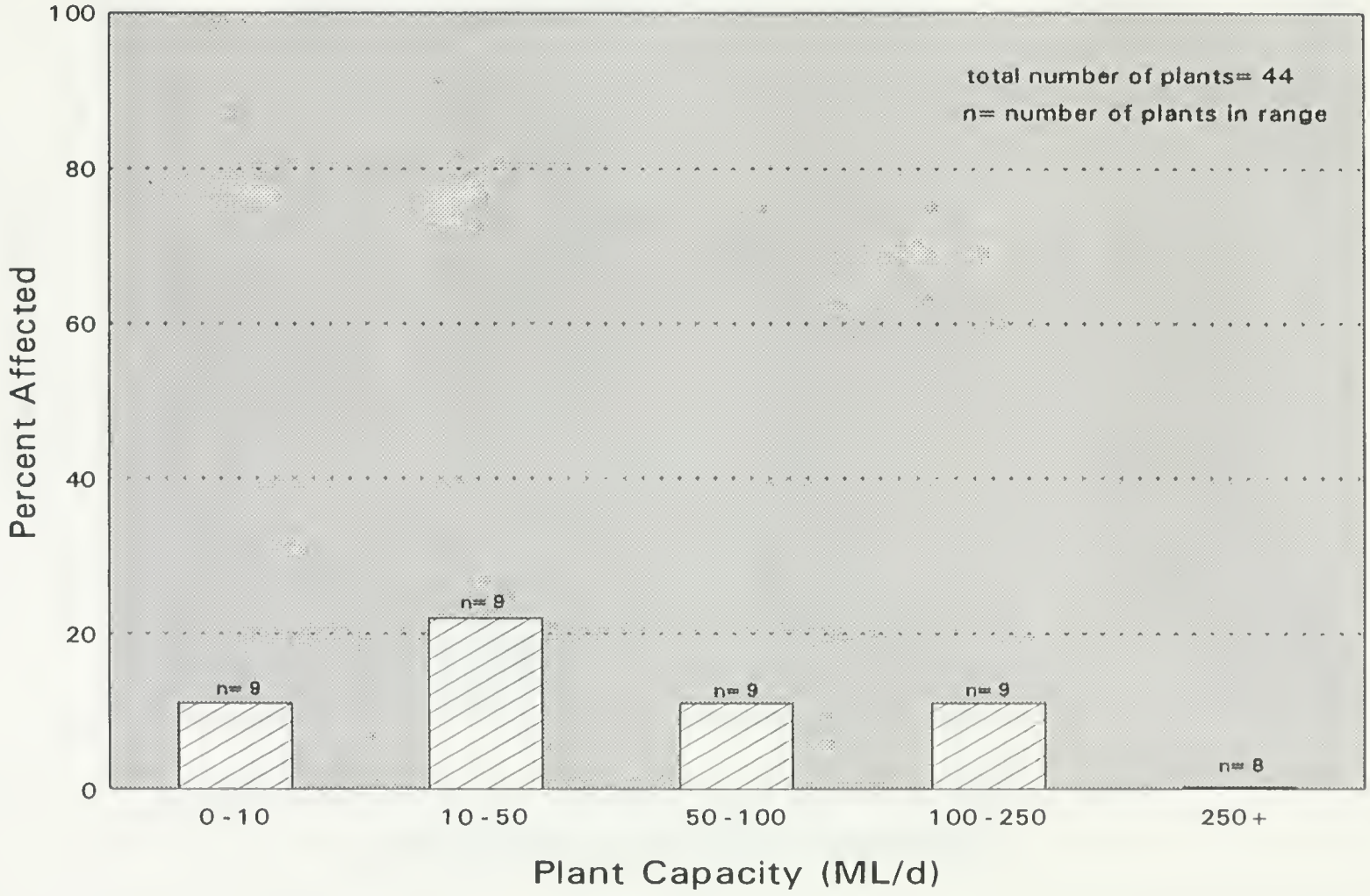
Measurement of Chemical Consumption

Percentage of Plants Affected in Given Capacity Range



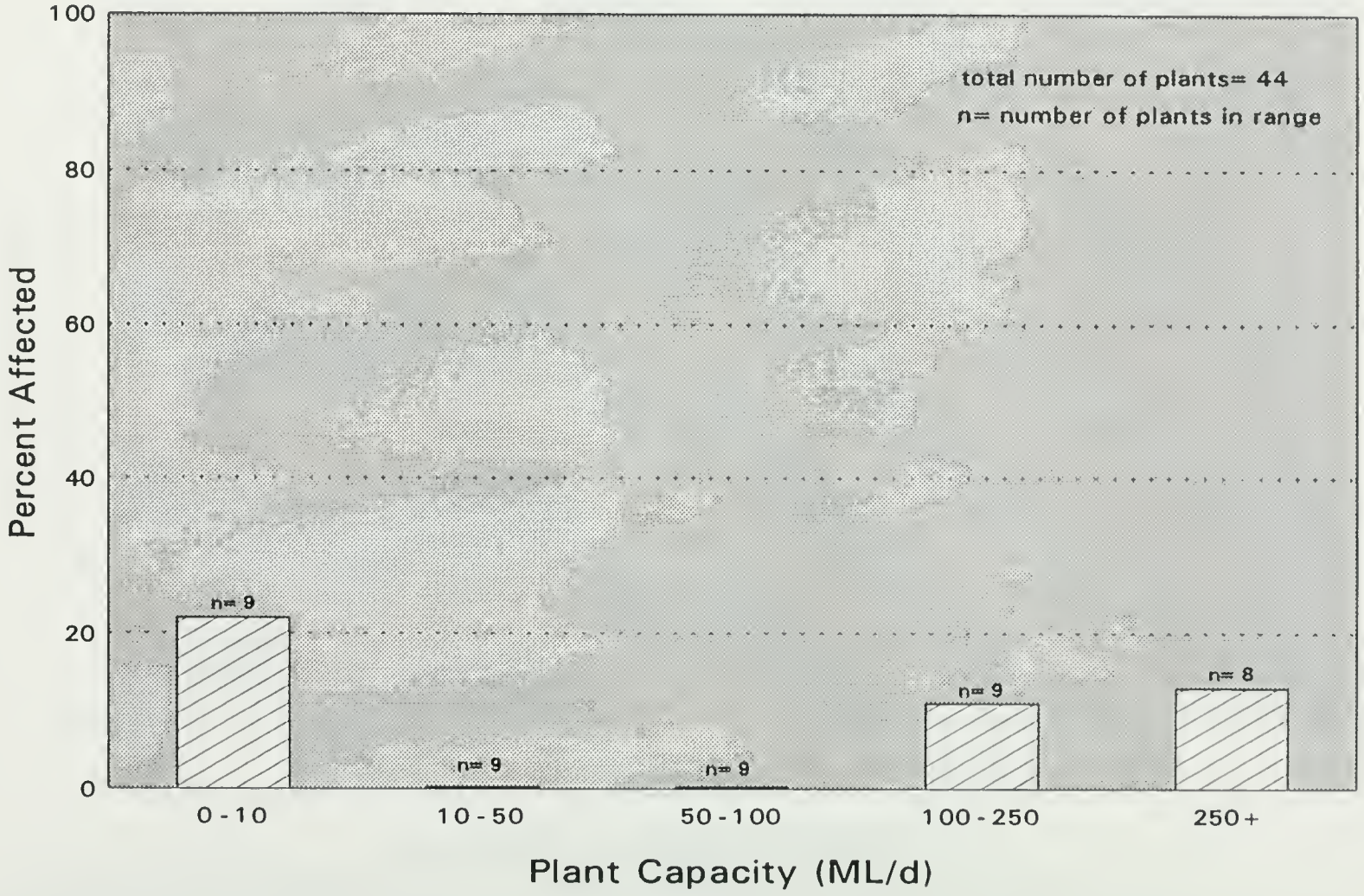
Physical Deterioration

Percentage of Plants Affected in Given Capacity Range



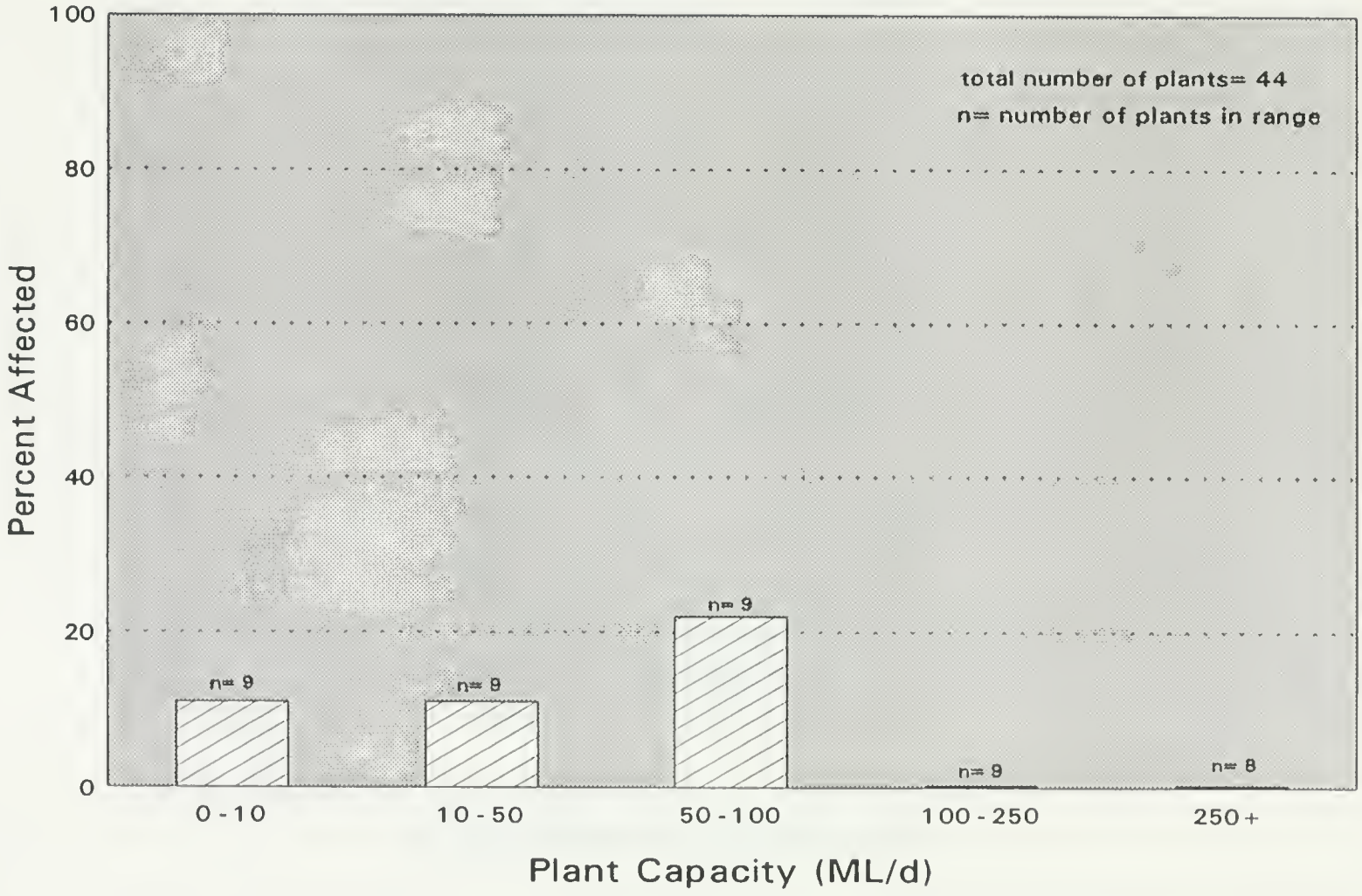
Chemical Storage Facilities

Percentage of Plants Affected in Given Capacity Range



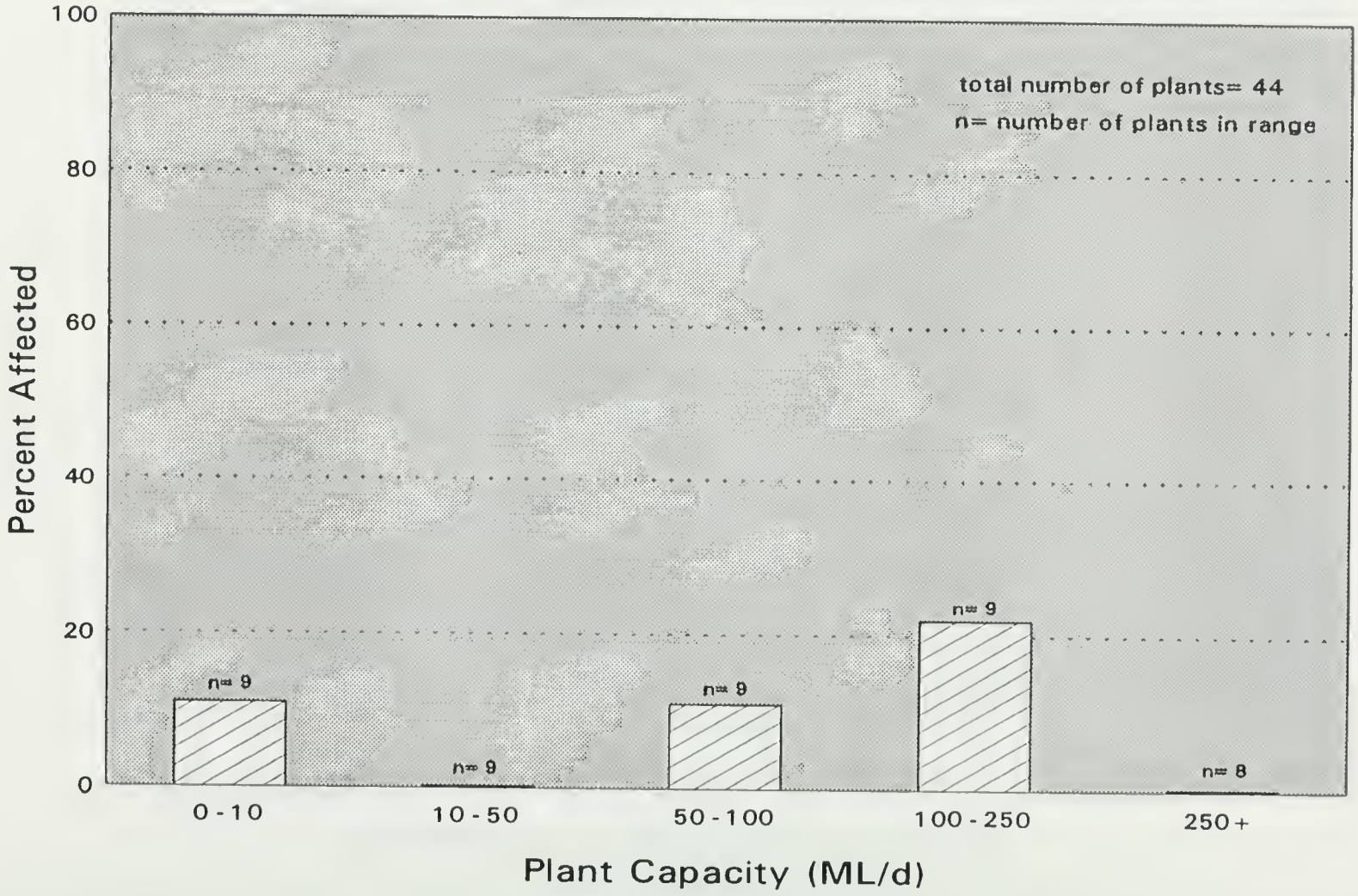
Inspection and Maintenance

Percentage of Plants Affected in Given Capacity Range



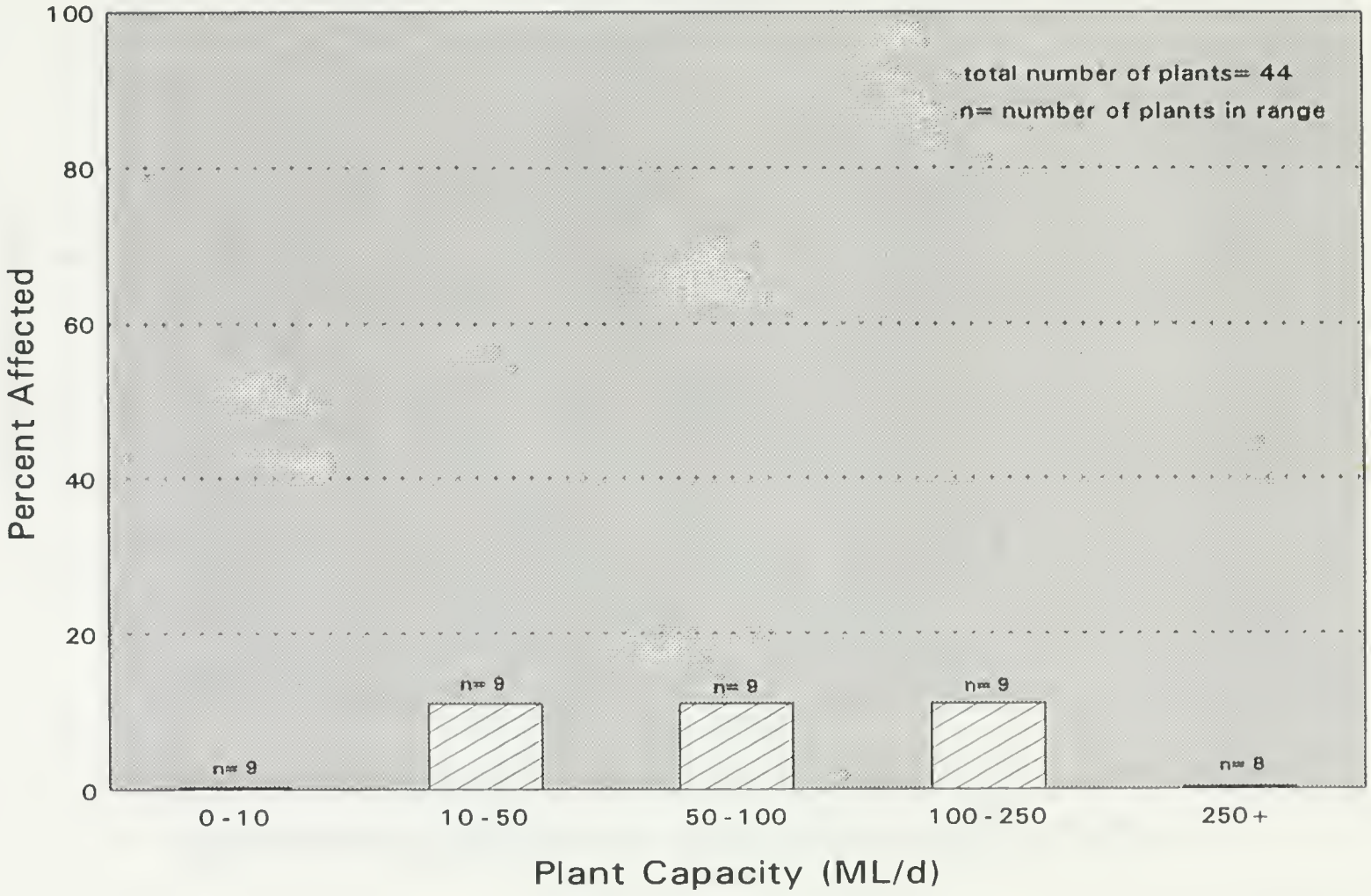
Emergency Planning

Percentage of Plants Affected in Given Capacity Range



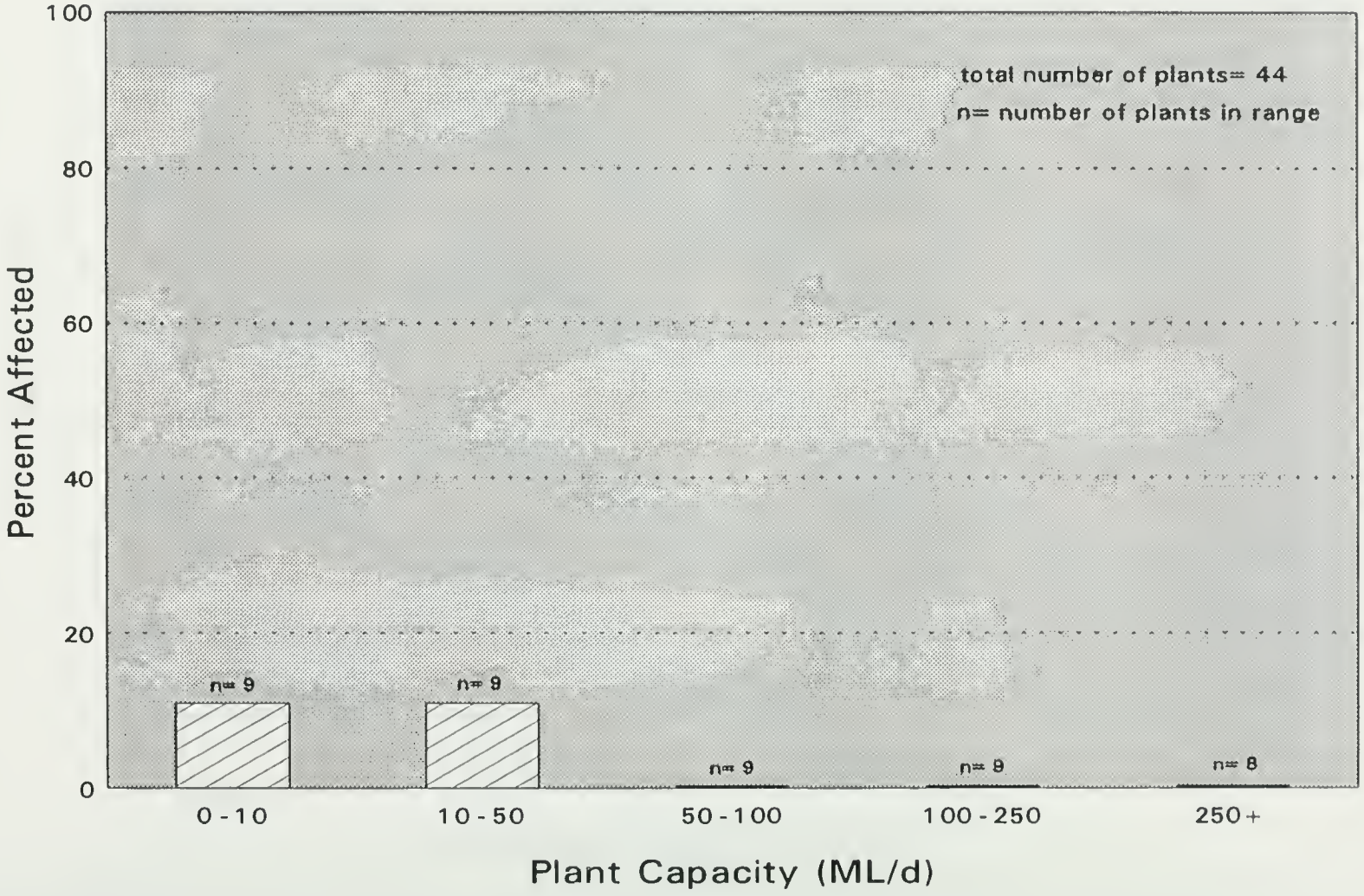
Sampling Procedures

Percentage of Plants Affected in Given Capacity Range



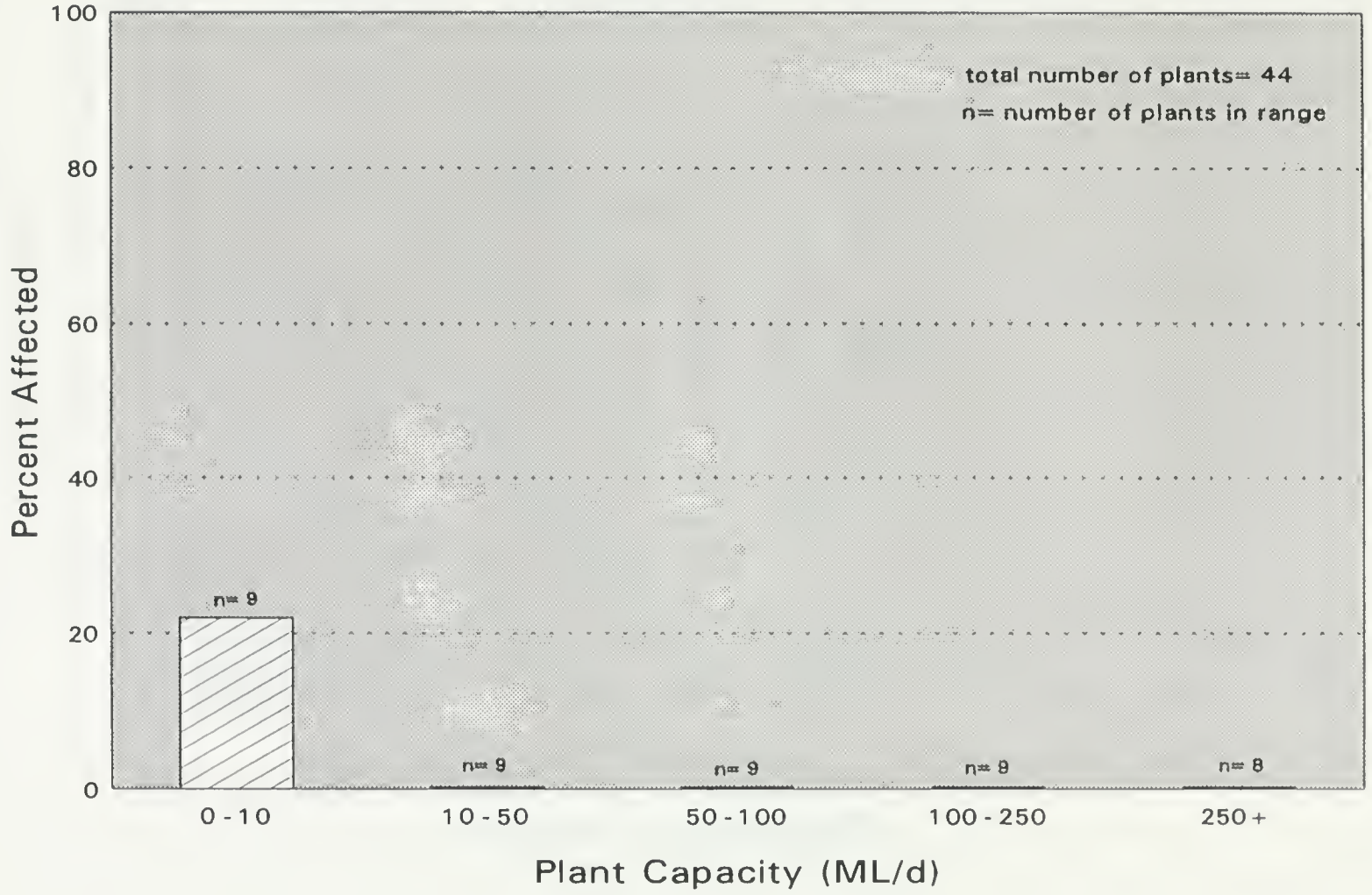
Standby Equipment and Instrumentation

Percentage of Plants Affected in Given Capacity Range



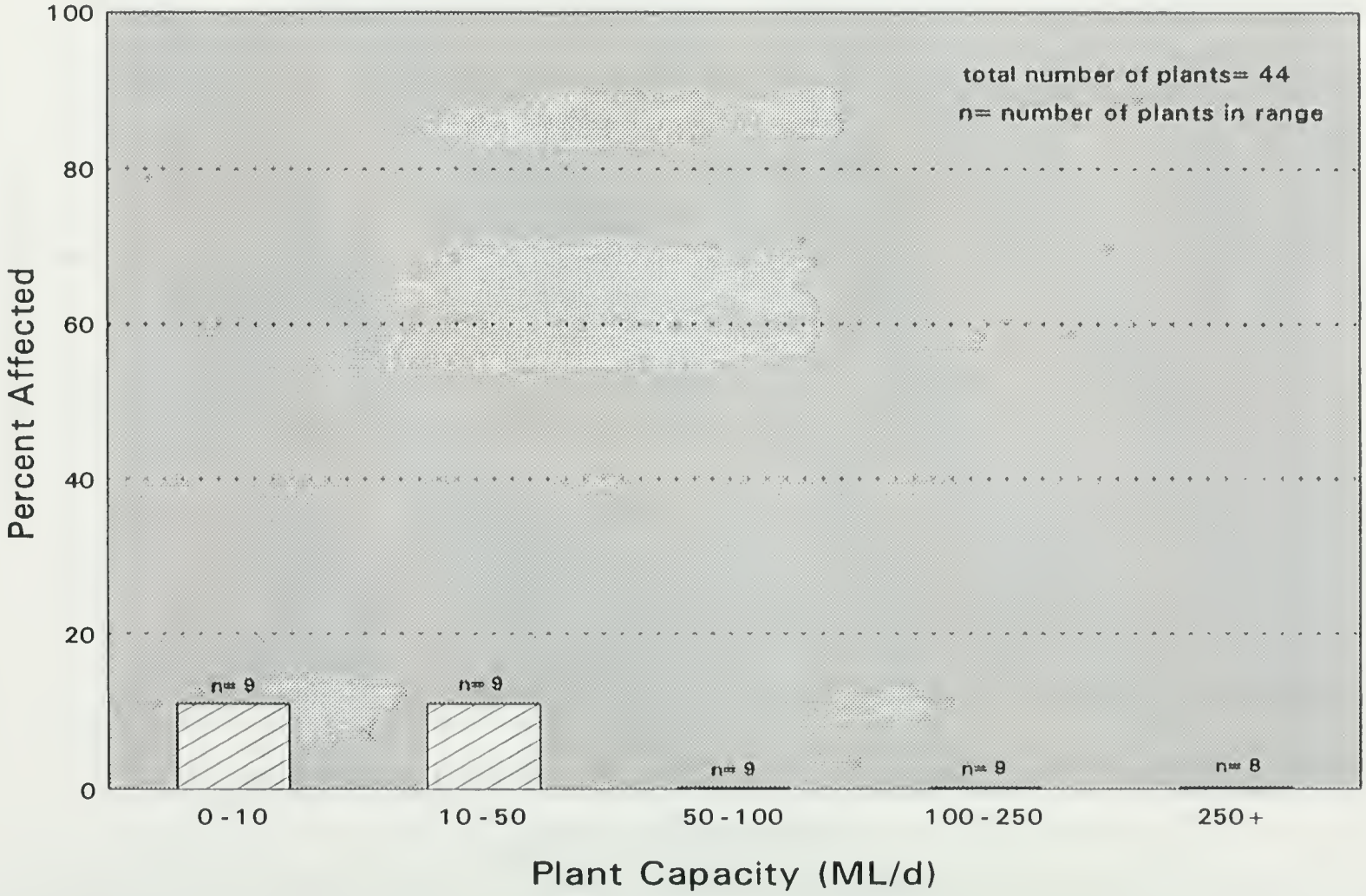
Plant Security

Percentage of Plants Affected in Given Capacity Range



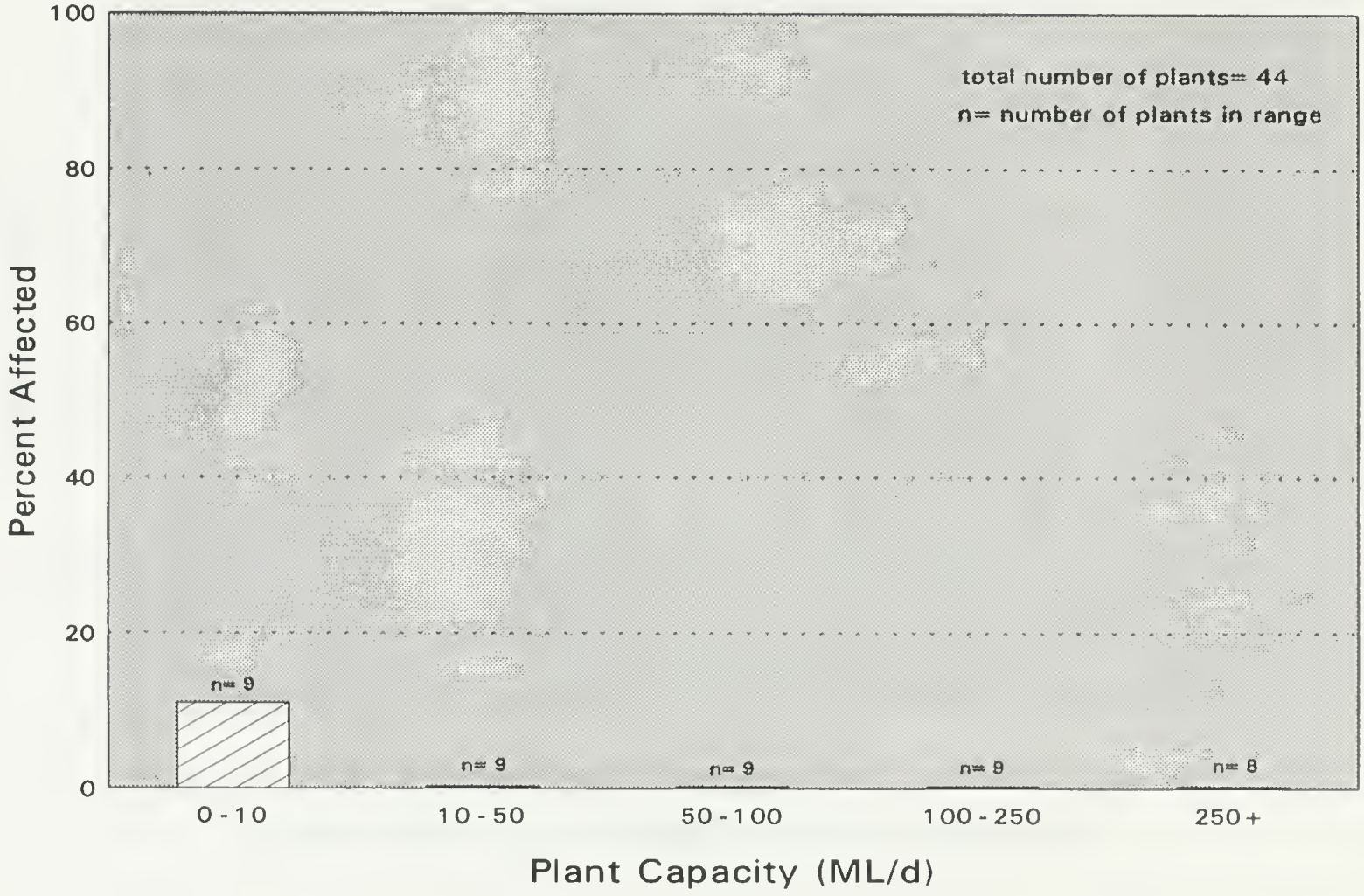
Level of Staffing

Percentage of Plants Affected in Given Capacity Range



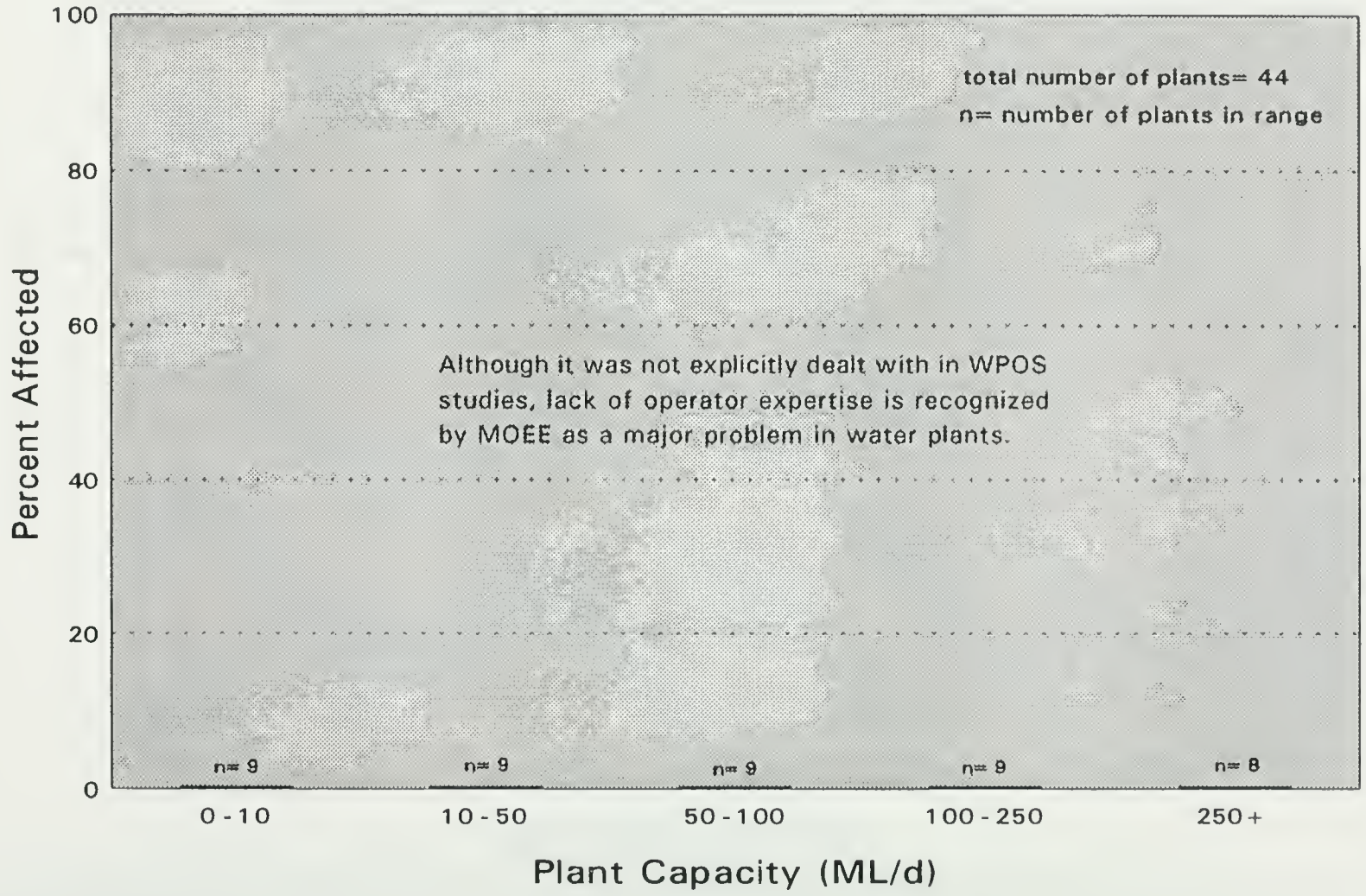
Standby Power

Percentage of Plants Affected in Given Capacity Range



Operator Knowledge and Expertise

Percentage of Plants Affected in Given Capacity Range



APPENDIX II

OPTIMIZATION PROTOCOL AND GENERAL TERMS OF REFERENCE

WATER PLANT OPTIMIZATION STUDY

OPTIMIZATION PROTOCOL
INCLUDING
GENERAL TERMS OF REFERENCE
FOR THE
PLANT CONSULTANT

Ontario Ministry of the Environment
Water Resources Branch
August 1986

06/04/87 (REV. 1)

WATER PLANT OPTIMIZATION STUDY

This document was prepared by K.J. Roberts, R.B. Hunsinger, and G.W. Martin of the Ministry of the Environment (MOE) Water Resources Branch and W.J. Hargrave of Gore & Storrie Limited. Revisions were carried out in conjunction with G. Sigal of R.V. Anderson Associates Limited and J. Budziakowski of the MOE Environmental Approvals and Land Use Planning Branch.

Ministry of the Environment
Water Resources Branch
Drinking Water Section
1 St. Clair Avenue West
Toronto, Ontario
M4V 1K6

06/04/87 (REV. 1)

Introduction

The information contained herein consists of a preamble and general terms of reference for the "Plant Consultant".

Basic Premise of the Water Plant Optimization Study

The majority of drinking water supply facilities in Ontario have treatment directed at microbiological disinfection and/or removal of suspended material.

The purpose of the Water Plant Optimization Study (WPOS) is to document and review the present conditions and determine an optimum treatment strategy for contaminant removal at the plant, with emphasis on the removal of particulate materials and disinfection processes.

The following items relate to the emphasis on particulate removal in a plant evaluation:

- Organic contaminants (dioxins, PAHs) are associated, at least in part, with particulates.
- Particulates themselves have health-related limits (turbidity/bacteria).
- In striving for excellence in water treatment, it is important to examine all possible approaches, but first optimum use should be made of the processes already in place.

The Drinking Water Surveillance Program (DWSP) is a continuously updated base of information on Ontario water plants and water quality. Appended herewith is a detailed description of the DWSP and the DWSP Questionnaire (Appendix A). In connection with the DWSP, a plant investigation and process evaluation study is required for each plant entering the program.

The Drinking Water Surveillance Program and the Water Plant Optimization Study are being co-ordinated for the following reasons:

- Some of the components of interest are the same, and cost savings can be realized.
- The DWSP should focus on plants which have been optimized and are producing the best possible water; documentation of plants which are known to be inefficient is non-productive.

General Information

1. Operator training and certification is an important component of plant optimization. Plans are already underway with the MOE/Municipal Engineers Association (MEA) to implement such a program.

2. The mechamism for ensuring ongoing optimization will be through an annual inspection by MOE staff or consultants, or a combination of the two.

3. The study has been organized with a team approach in mind; thus, progress reports and a meeting with the Project Committee are required as the work progresses.

4. It is not the intent of this study to provide a detailed implementation scheme for plant rehabilitation; however, it is necessary to scope the feasible short and long-term process modification, if required, to achieve optimum disinfection and contaminant removal.

5. All information provided in the study must conform to the Ministry's "Metrication Guidelines for Consulting Engineers", and existing information used for all designs, drawings, specifications, etc., for this project must also be converted into metric (SI) units.

Organization

On the following page is an organization chart which describes the various groups involved in each plant study.

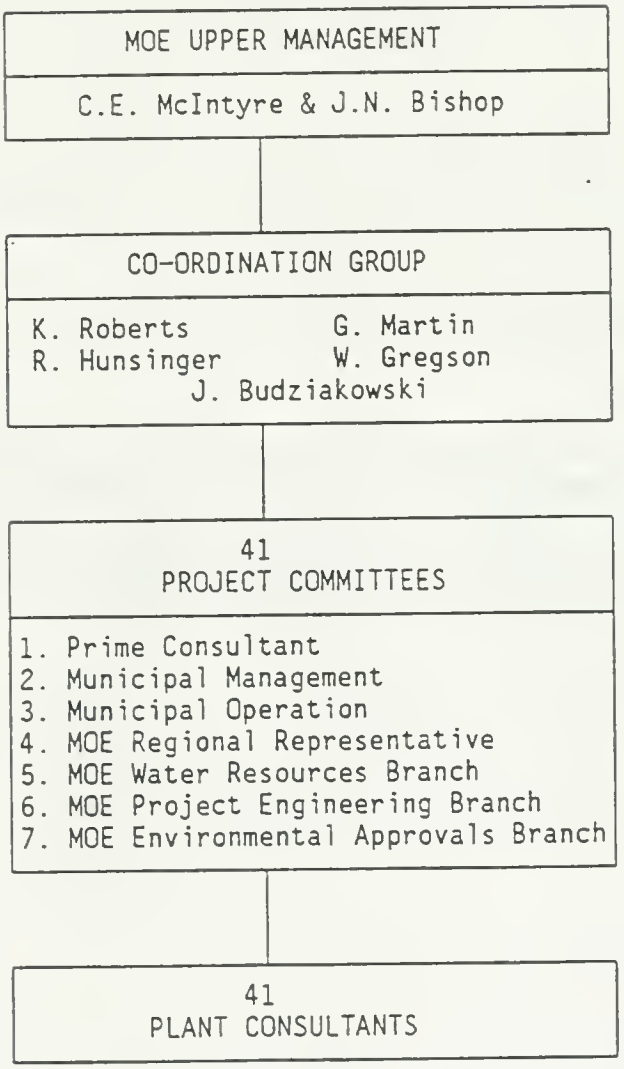
Project Committee

A "Project Committee" will be struck for each water plant. The "Project Committee" will consists of Municipal and MOE representatives and a "Prime Consultant". The "Project Committee" will formulate a set of specific terms of reference for the "Plant Consultant", using the "General Terms of Reference" contained herein as the basis. It is important that the same general approach be utilized for all plants; therefore, only some specific inclusions should be allowed in the plant specific terms of reference.

The "Project Committee" will direct the "Plant Consultant" in carrying out work described in the plant specific terms of reference. The "Project Committee" will also review the progress of the work and evaluate the final report.

WATER PLANT OPTIMIZATION STUDY

Reporting & Co-ordination



Prime Consultant

The "Prime Consultant" for the study will co-ordinate all of the water plant optimization studies by carrying out such tasks as:

- Setting up project committees
- Participate in development of the specific terms of reference for each plant
- Liaison with "Plant Consultants" regarding progress reports, meetings, and final reports.
- Preparation of a report summarizing the results of the 41 plant studies.

Plant Consultant

The "Plant Consultant" will carry out the data gathering, interpretating and recommendation steps outlined in Tasks 1 through 8.

The "Plant Consultant" must provide staff with extensive experience in evaluation of existing water treatment facilities who will maintain direct involvement in all phases of the project.

Purpose

To review the present conditions and determine an optimum treatment strategy for contaminant removal at the plant, with emphasis on particulate materials and disinfection processes.

Work Tasks

1. Receive an information package from the MOE. Review the information provided and meet with the MOE staff, if required, to discuss the project.

2. Document the quality and quantity of raw and treated waters.

3. Define the present treatment processes and operating procedures. Prepare a progress report on Works Tasks 1-3 for the Project Committee.

4. Assess the methods of efficient particulate removal which would utilize the present major capital works of the plant. Evaluate the particulate removal efficiency and sensitivity of operation, assuming optimum performance of the plant.

5. Assess current disinfection practices and possible improvement methods.

6. Describe possible short and long-term process modifications to obtain optimum disinfection and contaminant removal.

7. Prepare a draft report for the project committee's review.

8. Prepare the final report.

1. RECEIVE AN INFORMATION PACKAGE FROM THE MOE. REVIEW THE INFORMATION PROVIDED AND MEET WITH THE MOE STAFF, IF REQUIRED, TO DISCUSS THE PROJECT.

Elements of Work

(a) Receive an information package from the MOE concerning the plant and the study. This package includes a general terms of reference, a general table of contents for organizing the study in a manner consistent with other plant reports, the WPOS reporting tables and a copy of Ontario Drinking Water Objectives.

(b) Review the information and prepare for a meeting to initiate the work on the project, including preparation of a schedule of manpower and staff committments.

(c) Meet with the MOE to discuss the available data, the terms of reference, and the project staff and work schedule. If a consultant is carrying out more that one study it may not be necessary to meet with the MOE at the start of each study.

2. DOCUMENT THE QUALITY AND QUANTITY OF RAW AND TREATED WATERS.

Elements of Work

(a) Prepare a monthly summary of maximum, minimum, and average flows for the last three consecutive years (Table 1.0). Address any discrepancies which exist between raw and treated flow rates.

(b) Based on the above, briefly review and tabulate for the last three years, the monthly maximum, minimum, and average per capita flow for the total population served by the plant (Table 1.1). Compare the plant data with typical per capita flows for the local region. Indicate major consumers who may influence the figures.

(c) Document the methods of measuring the raw and treated water flow rates.

(d) Summarize, for the last three consecutive years, where available, the raw and treated water; turbidity, colour, residual aluminum/iron, pH, temperature and treatment chemical dosages (other than disinfection and fluoridation). The summary should indicate the monthly daily average and maximum and minimum day (Table 2.0).

For the same three year period, tabulate also the daily average for the typical seasonal months of January, April, July and October as well as other months in which problems with particulate removal occurred (Tables 2). Document enough data to define and evaluate those problems.

Record other data, such as particulate counting, suspended solids, and algae counting (Table 5.0) which could reflect on particulate removal efficiency.

Document the source and methods used in determining all information.

A comparison should be made between the plant and outside laboratory information to ascertain the relative validity of the data. For plant data, emphasis should be given to plant laboratory tests rather than continuous process control instruments.

(e) Summarize for the last three consecutive years, where available, the disinfectant demand, dosages (including all disinfection related chemicals and residuals) for all application points as well as fluoridation dosage and residual. The summary should indicate the monthly daily average and maximum and minimum day (Table 3.0).

For the same three year period, tabulate (Tables 3) the daily average for the typical seasonal months of January, April, July and October as well as other months in which problems with chlorine residuals and/or positive bacterial tests identified in Table 6. Document enough data to define and evaluate those problems.

Document the methods of dosage evaluation and residual measurements, and establish the validity of the data provided.

(f) Prepare a summary, based on at least three years of data, of the raw and treated water quality testing data for physical, microbiological, radiological, and chemical water quality information (Table 4). Document as much data as is needed to show possible seasonal trends in water quality. Where possible, show corresponding sets of raw and treated water quality information.

Document the source and methods used in determining all water quality information and establish the validity of the data, comparing plant and outside laboratory data.

(g) Tabulate, for the last three consecutive years, the raw and treated water bacterial test information at the plant (Table 6).

Document the source and methods used for all data provided.

(h) Document the water sampling systems (source, pump, line-material and size, vertical rise velocity sampling location) used in the plant (similar to DWSP Questionnaire in Appendix A).

(i) Prepare a summary of inplant testing including Test, Sampling Point, Testing Frequency, Reporting Frequency, Testing Instrumentation including calibration.

(j) Identify other water quality concerns, not related to particulate removal or disinfection, which should be considered as part of the assessment phase of this evaluation program.

3. DEFINE THE PRESENT TREATMENT PROCESSES AND OPERATING PROCEDURES. PREPARE A PROGRESS REPORT ON WORK TASKS 1-3 (8 COPIES), FOR THE PROJECT COMMITTEE.

Elements of Work

(a) Where drawings are available, assemble sufficient record drawings of a reduced size, to document the general site layout and the interrelationship of major plant components. If available, include a process and piping diagram (PAPD) of the plant operations.

(b) Prepare a simplified block schematic of all major plant components including chemical systems and indicating design parameters. Appendix B is an example of the required standard schematic.

(c) Prepare a photographic record of the plant facilities, illustrating all of the major plant components and chemical feed systems. The record should include approximately 30-40 coloured (9 cm x 12 cm) (or 10 cm x 15 cm) prints, suitably labelled. The progress and draft reports may include photocopies in lieu of the prints.

(d) Tabulate the design parameters for all the major plant components, with emphasis on the process operations, including chemical feeds. This information, as a minimum, must be consistent with the DWSP Questionnaire (Appendix A) and must be confirmed and verified by field observations. The design parameters should be evaluated at design, rated and actual operational flows.

(e) Prepare a summary of how the plant is operated, including chemical dosage control, such as jar testing information, filter backwashing procedures and initiation, and pumping and flow control.

(f) Document all reported and other apparent problems in plant operations and/or in the distribution system related to water quality. In addition list the health related parameters which exceed the Ontario Drinking Water Objectives (Table 7).

(g) Submit 8 copies of the progress report to the Prime Consultant for distribution to the Project Committee.

4. ASSESS THE METHODS OF EFFICIENT PARTICULATE REMOVAL WHICH WOULD UTILIZE THE PRESENT MAJOR CAPITAL WORKS OF THE PLANT. EVALUATE THE PARTICULATE REMOVAL EFFICIENCY AND SENSITIVITY OF OPERATION, ASSUMING OPTIMUM PERFORMANCE OF THE PLANT.

Elements of Work

(a) Assess the validity and implication of all information relating to particulate removal provided in Work Tasks 1 and 2 with emphasis on method, metering and sampling, etc.

(b) Using information provided in Work Tasks 1, 2 and 3 evaluate the plant's particulate removal efficiency. The basis of minimum particulate removal should be 1.0 F.t.u. It should, however, be recognized that it is desirable to strive for an operational level which is as low as is achievable.

(c) Conduct an evaluation of possible optimum performance alternatives. Include jar testing using established industry practice.

(d) Evaluate the feasibility of optimum removal using the existing plant capital works. This evaluation should consider the worst case water quality conditions, even though field testing data may not be available during the initial phase of the study (see Work Task 7).

(e) Describe the operational procedures, management strategies, and equipment required for various feasible alternatives. Estimate chemical dosages, level of operational expertise, and sensitivity of operation of the alternatives.

5. ASSESS CURRENT DISINFECTION PRACTICES AND POSSIBLE IMPROVEMENT METHODS.

Elements of Work

(a) Assess the validity and implication of all information relating to disinfection provided in Work Tasks 1, 2 and 3 with emphasis on method, metering and sampling etc.

(b) Using the information provided in Work Tasks 1, 2 and 3 evaluate the plant's ability to disinfect the water. The basis of minimum disinfection should be to ensure a water quality as described in the Ontario Drinking Water Objectives.

(c) Conduct an evaluation of possible optimum disinfection procedures for the plant, with consideration also given to the reduction of chlorinated by-products in the treated water.

(d) Evaluate the feasibility of the various alternatives using the existing plant capital works.

(e) Assess the relative merits of the alternatives. Describe the operational procedures, management strategies, and equipment required for the feasible alternatives. Estimate chemical dosages, level of operational expertise, and sensitivity of operation for the alternatives.

6. DESCRIBE POSSIBLE SHORT AND LONG-TERM PROCESS MODIFICATIONS TO OBTAIN OPTIMUM DISINFECTION AND CONTAMINANT REMOVAL.

Elements of Work

(a) Prepare a list of modifications which should be considered for detailed implementation evaluation. Provide an estimated cost and possible schedule for implementation for each of the proposed modifications.

It is not the purpose of this study to provide a detailed implementation scheme for plant rehabilitation. It is, however, necessary to scope the feasible short and long-term process modifications required to achieve optimum disinfection and contaminant removals.

(b) Incorporate (a) above in the draft report.

7. PREPARE A DRAFT REPORT FOR THE PROJECT COMMITTEE'S REVIEW. (8 COPIES).

Elements of Work

(a) The report must include all information for Work Tasks 1-6.

The information must be organized and presented in a logical and co-ordinated fashion. A general table of contents (Appendix C) is provided for organizing the material in a manner consistent with other plant reports.

Submit the draft report for review by the Project Committee.

(b) Meet with the Project Committee on site at least one week after submission of the report.

(c) Prepare a separate letter report containing recommendation(s) concerning the need for additional field testing to cover quality conditions not available during the period of this study. The Project Committee may decide to delay completion of the final report until field data can be obtained to confirm the predictions of performance for the worst case water conditions.

8. PREPARE THE FINAL REPORT.

Elements of Work

(a) Conduct additional field testing if required. Discuss the implementations of the results with the Project Committee if the results differ from the predicted performance.

(b) Amend the report as per review comments, incorporating additional field data if required.

(c) Submit 25 copies of the final reports (including the colour photographs) to the MOE for distribution.